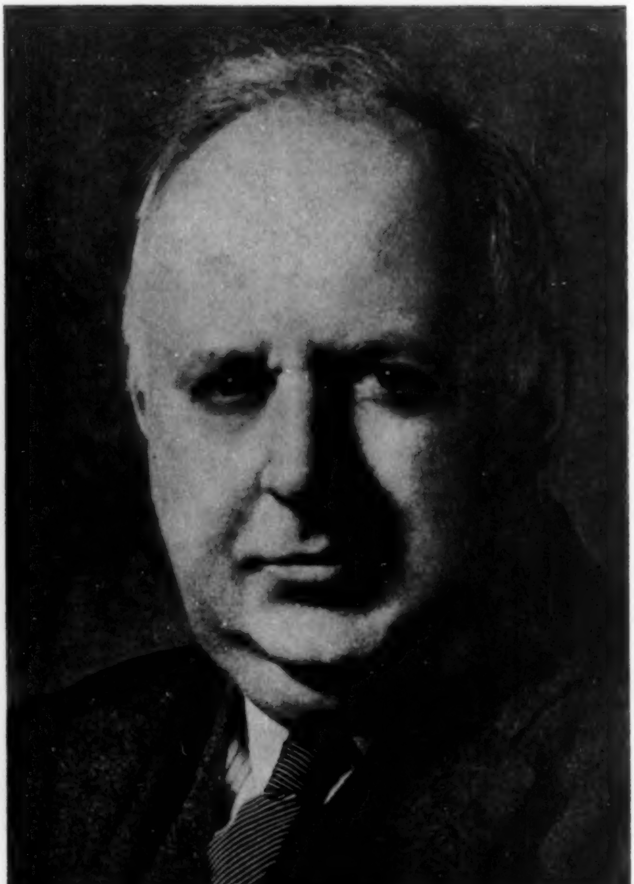
SCIENCE EDUCATION



GEORGE CLAYTON WOOD

VOLUME 42 DECEMBER, 1958 NUMBER 5

SCIENCE EDUCATION

THE OFFICIAL ORGAN OF

The National Association for Research in Science Teaching
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SCIENCE EDUCATION

VOLUME 42 DECEMBER, 1958 NUMBER 5

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After examining the dynamited ruins of the racially integrated school at Osage, West Virginia, the noted news commentator Drew Pearson reported he found a copy of the Wood and Carpenter general science textbook. It almost alone represented what had been a science classroom. This incident attests to the present use of what has been possibly America's best known and widely used general science textbook series over a period of years.

Dr. George Clayton Wood was born in Mexico, Oswego County, New York, February 2, 1878, the son of Rev. George W. Wood and Jane Horigan. He graduated from the St. Johnsville High School in 1895, entered Syracuse University in 1896, and received his A.B. degree in 1900. Oddly enough, he received his Ph.D., majoring in history, from New York University in 1918. As Dr. Wood explains it, his thesis was written during the time when it was considered very seriously dropping Biology from the New York City public schools. Having a license to teach history and being very much interested in that area, Dr. Wood completed the requirements for a Ph.D. in history by writing a thesis entitled: *Congressional Control of Foreign Affairs—1775–1789.*

During 1900–02, Dr. Wood was principal of the Jefferson Street Grammar School, Little Falls, New York. In 1902–03 he taught Biology in the Port Richmond High School, Staten Island, New York. From 1903 to 1914, Dr. Wood taught Biology and history in the Boys' High School in Brooklyn. While at Boys' High School, he was Chairman of a committee that wrote a new syllabus in Biology. He served as Head of the Department of Biology at Alexander Hamilton High School, Brooklyn, 1914–25.

In 1915 the Board of Superintendents appointed Dr. Wood a member of a committee to write a new syllabus in Biology for the New York City High Schools and the following year appointed him a member to write a syllabus in Hygiene for the New York City Schools. In 1922, he was appointed a member of a committee to write a general science syllabus. Later he was a member of another committee to revise the earlier general science syllabus. In 1924 the New York State Department of Education appointed him Chairman of a committee of five persons to write a three-year syllabus in general science covering the 7th, 8th, and 9th years in the junior and senior of the State of New York. During 1930–32 he was a member of a New York State committee to write a syllabus in Biology. He was a member and served as a reader of examination papers of the College Entrance Examinations Board in Botany and Zoology, 1910–13. He served as assistant examiner to the New York City Board of Education, including examiner in oral and personality examinations. Membership in other committees included: School Science Survey (1920); Requirements for Laboratory Assistant Examinations in Biology; Criteria for Estimating

Candidates Trying Examinations in Biology for Teaching in New York City Schools; Appeals Committee of the Board of Examiners, New York City Board of Education; Chairman and member of Committee to write New York State Regents Examinations in Biology (1932–36); Chairman of Committee to Write New York State Regents Examinations in General Science from 1926 to end of period when such examinations were given; Committee to Select Science Textbooks for New York City Schools (several times Chairman); New York City Supply List for Science; Correlation and Integration of Science; Standing Committee on Science; Teachers Science Committee; Science Sequence of New York Association of Biology Teachers. In 1927 he was appointed a member of a committee to supply motion pictures in general science for the Eastman Kodak Company. Many of these films were used in the New York City Schools. Long interested in the use of motion pictures in teaching science, Dr. Wood wrote several motion picture guides as well as scenarios.

In 1925 Dr. Wood went to the New James Monroe High School in the Bronx as Chairman of the Biology and General Science Department. Here he remained until his retirement in 1939. At James Monroe by 1930 he had organized a teaching corps of thirty-seven teachers, teaching over 6,000 pupils in a 12,000 pupil enrollment. This was the largest department of its kind in New York City. In 1920 he became President of the Department of Botany, Zoology, and Agriculture of the Brooklyn Institute of Arts and Sciences, composed of over 14,000 members, the largest institution of its kind in the world. He served in this capacity for over 20 years. Here for many years he taught courses in Methods of Teaching Biology, Methods of Teaching Hygiene, and Methods of Teaching General Science in the Junior and Senior High Schools. These courses were co-sponsored by Adelphi College and the Brooklyn Teachers Association. He also taught these same courses at Hunter College 1928–34 where they were sponsored by the Bronx Teachers Association.

Membership in organizations includes New York Biology Teachers Association (State and City); New York General Science Teachers Association (State and City); New York High School Teachers Association; Teachers Alliance of New York City; Brooklyn Institute American Association for the Advancement of Science; Torrey Botanical Club; National Education Association; National Science Teachers Association; New York Writers Club; National Association for Research in Science Teaching. Dr. Wood is listed in *American Men of Science.* He served as President of the New York Biology Teachers Association 1918–20. While not a charter member of N.A.R.S.T., Dr. Wood was one of its first elected members and during its early years made many fine contributions at its annual meetings.

Dr. Wood has been a prolific writer and lecturer along science education lines. Much of this writing has been in numerous committee reports, syllabi, monographs, motion picture guides, scenarios, and radio script. Articles have been published in numerous magazines, a partial list of which includes: *Science Education, Educational Screen, Torrey Club Magazine, Health Digest, Teaching Biologist, High Points of the New York City Board of Education, Junior-Senior High School Clearing House, School Science and Mathematics, Bulletin of the Brooklyn Institute of Arts and Sciences, The Outlook,* and *Macrocosm Magazine.* He has also had many articles appearing in newspapers both in New York City and State, New Orleans, and St. Petersburg, Florida.

Lectures have been given to thousands of groups—New York City, New York State, N.A.R.S.T., Peking, China, and Tokyo, Japan.

Nationally Dr. Wood is best known for his series of General Science and Biology text books (co-authored) by the late Dr.

Harry A. Carpenter, and published by Allyn and Bacon. The first book of the series appeared in 1927. At first it was a three book series for general science in the 7th, 8th and 9th grades. As a three-book series in science it was the first three-book series ever published. Later it became a four-book series when a Biology textbook was added. Titles of the series: *Our Environment: Its Relation to us; Our Environment: How We Adapt Ourselves to It; Our Environment: How We Use and Control It; and Our Environment and the Living Things In It* (a biology text first published in 1938). Teachers' Manuals, Pupil Discovery Books, and Objective Tests were prepared for each of the four books. The books have been constantly revised, with one such revision to appear in 1959. The series of books were immediately very popular and during the past thirty years have kept the national lead in copies sold—sales amounting to considerably over 3,000,000 copies.

Dr. Wood married Miss Adelaide Griffin of Utica, New York, December 26, 1900. To this union one son was born, Dr. Robert G. Wood, now owning and operating a motel near Remsen, New York. Mrs. Wood died in October, 1940. Dr. Wood married Miss Elizabeth Bennett of Waycross, Georgia in October, 1942. Dr. Wood moved to St. Petersburg, Florida in 1940 after living thirteen years in Riverdale-on-the-Hudson, New York. He is a member of Christ's Methodist Church in St. Petersburg and a member of the official board. Presently he is President of the St. Petersburg Men's Garden Club and was recently President of the Board of Governors of the Peoples Open Forum. Dr. Wood continues very active, having taken part in 14 plays put on by the local Little Theater group, cultivating fruit trees and flowers on his acre plot, "dabbling" in Real Estate, giving the annual Abraham Lincoln address, and revising his science books.

A brief summary of Dr. Wood's philosophy of science teaching and his numerous and significant contributions to the areas of science education may be stated as follows:

He has been particularly interested in stressing the scientific method and a practical approach in teaching science. The development of science attitudes by pupils is more important than the subject-matter they learn. Dr. Wood says: "I believe in teaching the pupil and not the subject; that putting the pupil in the most direct contact with his environment through the use of many demonstrations and pupil experiments, with emphasis upon the discovery of the many relationships among the factors of the environment through emphasis upon the dramatic methods of teaching. The discovery of laws and principles as a result of this kind of teaching which may be applied to the daily conduct of the life of the pupil has been my constant goal through forty years of teaching science."

In a report to the Supervisor of High Schools in New York City, Dr. Wood made plea for general science and a four-year science sequence, stating that general science: (1) more nearly matches the everyday experiences of the pupils than any other science or any other subject for that matter; (2) is adapted more nearly to the capacity of the 9th year pupil than any other science; (3) causes a pupil to do more independent thinking than any other science for the 9th year; (4) gives greater range for the development of skills and scientific attitudes than any other 9th year science; and (5) it is par excellence the basic science for the 9th year because here the greatest mortality is to be found.

Dr. Wood has been widely known as one of the pioneers in the teaching of General Science in New York City and had a leading part in shaping the policies in the teaching of General Science in New York State. For many years Dr. Wood stressed the adoption of a science sequence and wrote many articles and made many addresses advocating a sequence.

Dr. Wood made many very significant

contributions to the teaching of General Science and Biology both in New York City and New York State through his membership on three different syllabi committees and his chairmanship of the New York State General Science Committee. He was directly instrumental in the development of a four-year sequence for New York State schools and the ultimate sequence allotment in New York City.

Nationally and even internationally, Dr. Wood's greatest contributions have been through the popular *Our Environment* science series which have been so widely and extensively used. The only science books ever used by hundreds of thousands of youngsters have been the *Our Environment* books.

Through these books the philosophy of Dr. Wood has given the real meaning of science to millions of boys and girls by "stressing the great fundamental concepts of Matter, Energy, and Work—three factors which are considered as a basis or connecting cord upon which are strung as beads upon a necklace every factor of our environment. Matter, fundamental substance visible to us, acted upon by energy, resulting in the World's Work, which is almost entirely the task of moving matter from one place to another."

A distinguished author and a noted pioneer in general science and biology in New York State and New York City, it is with great pride that Dr. George Clayton Wood is honored by being made recipient of the Thirteenth Science Education Recognition Award.

CLARENCE M. PRUITT

DEMONSTRATION OF A MAJOR CONCEPT IN GENERAL SCIENCE

GEORGE C. WOOD
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FORTY years of teaching science has firmly convinced me that a spectacular dramatization of a process or a principle is the very best way of putting a fundamental concept into the minds of pupils to stay. The demonstration outlined below well illustrates what I mean by dramatization and with it is well shown a unifying principle which will greatly aid the pupil to see with his mind as well as with the eyes.

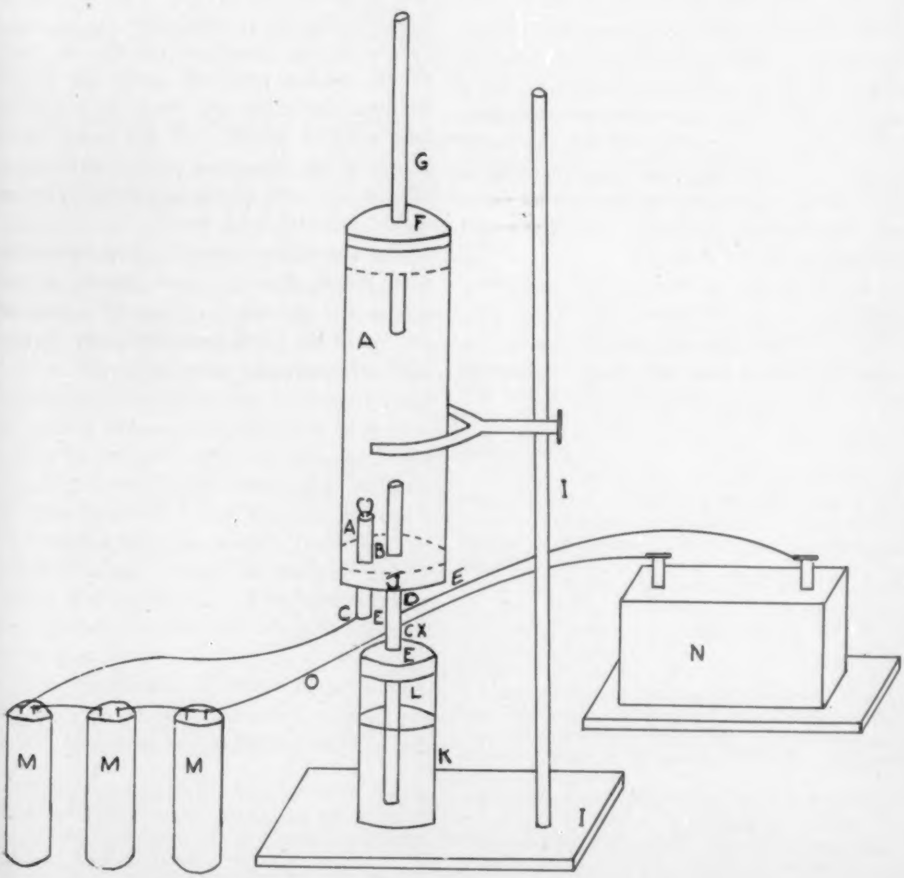
In my teaching of general science I found the most common thing that met the eye was the environment, which was very largely made up of *matter*. This matter was most often inert, but it was also often moved from place to place. Something moved it through the instrumentality of water, steam, gas, electricity, etc. In short, *energy* moved matter whenever it was moved. The result was *work*. In introducing the course of study it was felt that the pupil should have a clear concept of the meaning of matter, energy and work with numerous examples of each, but also he should get a clear concept of the interrelation between these three concepts, the sequence of events in the environment when these three concepts are brought into action and above all the unifying effect upon the mind of the pupil when he clearly perceives these relationships. Finally, the impact of the understanding of this unifying effect has an enlightening influence upon all his subsequent thinking and study in the field of science.

Below is the outline of the items used in the demonstration, how they are used, the

results obtained and observed and their application to subsequent work of the course of study.

Here is what I did. I secured a six inch piece of the leg of a brass bedstead one and one-half inches in diameter (A). In one end was fitted tightly a two-holed rubber stopper (B). Through one hole was forced a 4″ piece of glass tubing (C) as shown in diagram. A second short piece of tubing (D) was forced through the second hole for a distance of about 2″ above the stopper. Two 1′ long (E, E) wires (German silver) were run through this last tube to protrude above one end for about ⅜″ and bent as shown in the drawing. These wires are held solidly in place by stuffing the tube full of plaster of paris. A plunger or piston is made from a one-holed rubber stopper. This must fit quite tightly in the end of the brass tube. A lead pencil (G) is forced through the hole of the stopper to be used as a handle.

A 4″ length of rubber tubing is fitted over lower end of the 4″ glass tube. A pinch cock (X) is attached to upper end of this rubber tubing. The brass tube is now held in place by clamp and ringstand (I). The two holed stopper (J) with wires is set into the lower end of the brass tube. The longer glass tube with rubber tubing and pinch cock is lowered into a wide mouthed bottle (K) after being fitted through a rubber stopper (L) to close this



bottle, which is filled ⅔ full of a mixture of equal parts of gasoline and alcohol.

One of the wires is now attached to the binding post of one of three or four dry cells connected in series (M). The other wire is connected with a binding post of a spark coil (N). A second short wire (O) connects the other binding post of the spark coil to the free binding post of the last dry cell in the battery. You are now ready for action. Opening the pet cock draw up into the brass tube a supply of the gasoline-alcohol mixture by placing the mouth over upper end of brass tube and gently drawing in the breath. This fills the cylinder with fuel. Immediately force the piston quite firmly into the open end of the brass cylinder.

The description up to this point is long, but the action when you press the contact point on the spark coil is instantaneous. A loud report is heard, accompanied by a sheet of flame and a pronounced explosion. The piston is forced out of the tube with great force and may make a visible dent in the ceiling. The surprised look on the faces of the pupils is marked. Questions and discussion follow in waves.

A discussion of the results and their implications would take more room than *Science Education* can possibly spare. A wise instructor can see many and apply them at his leisure. A few high points may be stressed here. First, the brass tube, and all other items in apparatus is matter in solid form. So is the fuel mixture also matter but in a liquid form. The explosion is also matter in a gaseous form. A transformation in matter has taken place. Matter is generally inert, but some when burned is changed. Stored energy becomes active or kinetic. Heat and flame are produced. Gases expand and movement takes place. Matter (piston) is moved and work is done (the piston is thrown to the ceiling) because matter is moved from place to place.

The relationships between matter, energy and work are well shown here. The cause and effect relationships are clearly set forth. The sequence of events in the transformation of matter to energy to work is evident. The unifying impression of seeing so many events taking place so quickly in such closely related processes gives the pupils the idea that they are living in a closely knit complex world. All are based upon a few simple processes and events taking place every hour of the day in our present highly industrialized world.

The above demonstration was invariably used during the very first periods of the course and formed the basis of a general concept of the whole course of study. Reference to it was made scores of times.

AN INVESTIGATION OF TWO METHODS OF MEASURING THE READING DIFFICULTY OF MATERIALS FOR ELEMENTARY SCIENCE *

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THE PROBLEM

THE purpose of this study is to determine whether the measurements made with readability formulas of the reading difficulty of certain passages from textbooks for elementary science are more consistent than estimates made by reading experts of the reading difficulty of these same passages.

THE FACTOR OF READING DIFFICULTY

It is obvious to nearly all educators that textbooks have little value for students if they are too difficult to read. This viewpoint is stated in many journals. It has been made clear many times at reading conferences. Hence, it would be redundant to pursue the point further.

One would assume, therefore, that the reading materials that are available for use in schools would be written so as to be suitable with respect to reading difficulty. Yet research dealing with the reading difficulty of such material fails to yield evidence that shows that the levels of difficulty of much of it are suitable for the students for whom it is designed. This seems to be true for textual materials in nearly all areas of subject matter.

The most extensive series of studies dealing with the reading difficulty of textbooks was undertaken by Mallinson and his colleagues in the area of science.[1,2,3,4,5,6,7,8,9,10]

In general the methods used in these studies followed the same procedure. A

* Paper presented at the Twenty-Ninth Annual Meeting of the National Association for Research in Science Teaching, Hotel Sherman, Chicago, Illinois, April 21, 1956.

1 George Greisen Mallinson, "Some Problems of Vocabulary and Reading Difficulty in Teaching Junior High School Science," *School Science and Mathematics*, LII (April 1952), 269–74.

2 George Greisen Mallinson, "The Readability of High School Science Texts," *The Science Teacher*, XVIII (November 1951), 253–6.

3 George Greisen Mallinson, Harold E. Sturm, and Lois Marion Mallinson, "The Reading Difficulty of Textbooks for General Physical Science and Earth Science," *School Science and Mathematics*, LIV (November 1954), 612–6.

4 George Greisen Mallinson, Harold E. Sturm, and Lois Marion Mallinson, "The Reading Difficulty of Textbooks in Junior High School Science," *School Review*, L (December 1950), 536–40.

5 George Greisen Mallinson, Harold E. Sturm, and Lois Marion Mallinson, "The Reading Difficulty of Textbooks for General Science," *School Review*, LII (February 1952), 94–8.

6 George Greisen Mallinson, Harold E. Sturm, and Lois Marion Mallinson, "The Reading Difficulty of Textbooks for High-School Biology," *The American Biology Teacher*, XII (November 1950), 151–6.

7 George Greisen Mallinson, Harold E. Sturm, and Lois Marion Mallinson, "The Reading Difficulty of Textbooks for High-School Chemistry," *Journal of Chemical Education*, XXIX (December 1952), 629–31.

8 George Greisen Mallinson, Harold E. Sturm, and Lois Marion Mallinson, "The Reading Difficulty of Textbooks for High-School Physics," *Science Education*, XXXVI (February 1952), 19–23.

9 George Greisen Mallinson, Harold E. Sturm, and Lois Marion Mallinson, "The Reading Difficulty of Unit-Type Textbooks for Elementary Science," *Science Education*, XXXIX (December 1955), 406–10.

10 George Greisen Mallinson, Harold E. Sturm, and Robert E. Patton, "The Reading Difficulty of Textbooks in Elementary Science," *Elementary School Journal*, L (April 1950), 460–3.

search was made to locate the titles of science textbooks designed for use at the grade levels or field of science under study. Since an analysis of all the textual material in all the textbooks thus located was impractical, a modification of the sampling technique suggested by Flesch [11] for use with his formula was employed. From each textbook the investigators selected one sample passage for each one hundred pages or fraction thereof, but not less than five passages from any one textbook. The number of pages in each textbook was computed by counting from the first page designated by an Arabic numeral to the last page of the last chapter. Pages upon which were found chapter endings, supplementary activities, and questions were included in the count. Pages upon which were found indexes, glossaries, and tables of contents were excluded.

The number of pages in each textbook was then divided by the number of samples to be taken from the book. In this way each textbook was divided into sections of an equal number of pages. A page was then selected from each of the sections by using a table of random numbers.

A one-hundred-word sample was taken from each page thus selected by counting from the first word of the first paragraph on that page. If the page contained no reading material, the sample was selected from the next page that did. Legends under illustrations on these pages were disregarded. These samples were then analyzed by the use of the Flesch formula.

The Flesch formula takes cognizance of the number of words in the sentences found in the sample passages, the number of personal references (we, they, etc.) in the passages, and number of affixes and suffixes (syllabification) to the words. These various aspects of sentence structure are measured in each of the one-hundred-word samples and are translated into a reading difficulty score by means of the formula. The reading difficulty score is converted, in turn, into a grade-level value of reading difficulty through use of a table provided for that purpose. An analysis of these measurements of reading of science textbooks leads to the following general conclusions:

1. The reading levels of many textbooks in science are too advanced for the students for whom they are written.
2. The differences between the levels of reading difficulty of the easiest and the most difficult textbooks in any area of science are significant.
3. In some textbooks of science whose average level of reading difficulty seems satisfactory, there are passages that would be difficult even for some college students.
4. Many textbooks of science contain nontechnical words that could be replaced with easier synonyms.
5. The levels of reading difficulty within the textbooks vary greatly. The earlier passages in the textbook did not seem to be consistently lower in the level of reading difficulty than the later passages.

All these reports tend to point to one fact. Although reading difficulty is an important factor in the learning process, a great number of books fail to be suitable in this respect for the students who use them.

MEASURING READING DIFFICULTY

Obviously, if the evidence produced by the studies just cited is correct it would seem that teachers should carefully evaluate textbooks for their levels of reading difficulty before selecting them for use. Such of course is done in many schools by means of any one of a number of reading formulas. In fact the use of reading formulas has become widespread and the literature is replete with reports emphasizing their values.

All these citations point to the fact that the use of the various readability formulas seems to be supported by the results that are obtained. However, there is not complete unanimity with respect to the value of readability formulas. Dissenting opinions are expressed quite frequently. One of the most pointed comments on the value

[11] Rudolph Flesch, *The Art of Plain Talk*. New York: Harper and Brothers, 1946. p. 205.

of readability formulas was made by Dr. Emmett A. Betts, formerly of the Reading Clinic of Temple University. On Friday, December 28, 1951, in the Junior Room of the Hotel Ritz-Carlton, Philadelphia, Pennsylvania, at a morning session of Section Q, at the Convention of the American Association for the Advancement of Science, Dr. Betts discussed the values of readability formulas with one of the authors of this report. Betts made the statement that it was a waste of time to use readability formulas to measure the difficulty of reading materials since any good teacher could tell the reading difficulty of reading materials by examining them. Apparently then there are two conflicting views concerning the use of readability formulas. The authors, therefore, decided to investigate these conflicting viewpoints using some of the samples of science materials selected by Mallinson and his associates in the studies already cited.

Those chosen were the ones taken from the series of science textbooks for use at the fourth through the eighth grade levels. A total of one hundred and ninety-nine samples from thirty-nine textbooks were thus obtained. The methods by which the samples were selected from the textbooks is described earlier.

EVALUATION OF SAMPLES BY READABILITY FORMULAS

On the basis of evidence obtained by an extensive search of literature it was found that the Flesch,[12] Lorge,[13] and Dale-Chall[14] formulas seem to be among the most widely used and suitable for the type of analysis planned here.

Since the evaluations made by Mallinson and his associates with the Flesch formula were available for use in this study, it was necessary to work only with the two other formulas.

All these samples were then analyzed by the Lorge Formula. This formula is based on the assumption that the reading difficulty of material depends on the number of prepositional phrases, the average sentence length, and the vocabulary load which is determined by a count of words not common to the Dale List of 769 Words. These three factors of prediction are converted into an estimate of grade level of difficulty. The computations for the Lorge Formula are as follows:

> Average Sentence Length (number of words divided by the number of sentences) times .07, plus the Ratio of Prepositional Phrases (number of prepositional phrases divided by the number of words in the sample) times 13.0, plus the Ratio of Hard Words (number of hard words divided by the number of words in the sample) times 10.73, plus a constant, .6126, equals the Readability Index.

Following the analysis with the Lorge Formula, these same samples of science material were analyzed by the Dale-Chall Formula. This formula bases its prediction of grade level of difficulty on the average sentence length and vocabulary load determined by a count of words not common to the Dale List of 3,000 Words. These two factors are then converted into a reading difficulty score by means of the following computations:

> Average Sentence Length (number of words in the sample divided by the number of sentences) times .0496, plus the Dale Score (the number of words not on Dale List divided by the number of words in the sample times one hundred), times .1579, plus a constant, 3.6365, equals the formula score.

EVALUATIONS OF SAMPLES BY READING EXPERTS

In order to enlist the cooperation of reading experts in this study it was first necessary to obtain a list of supervisors or teachers who were considered reading experts. Letters were sent to the superintendents of

[12] *Ibid.*

[13] Irving Lorge, "Predicting Readability," *Teachers College Record,* XLV (March 1944), 404–19.

[14] Edgar Dale, and Jeanne S. Chall, "A Formula For Predicting Readability: Instructions," *Educational Research* Bulletin, XXVII (January 1948), 37–54.

one hundred large public school systems in Ohio, Michigan, Indiana, Illinois, Wisconsin and Iowa. The superintendents of these mid-western school systems were asked to recommend the most qualified person on their staff in the field of reading to assist in this study.

From the recommendations submitted by the superintendents ninety-two reading experts were asked to participate in the study.

The one-hundred-ninety-nine samples which had been analyzed by the readability formulas were then mimeographed in order to obtain ten copies of each sample. Twenty-one of these samples were selected at random and made into a set. A set was then sent to each of the ninety-two reading experts together with instructions for making the estimates of reading difficulty. A copy of the instruction sheet together with a sample reading passage follow:

INSTRUCTIONS

1. Read each sample carefully and estimate the grade level at which an average student could read it without difficulty.
2. Check the appropriate grade level of difficulty in the space provided.
3. If you do not think the sample would be suitable for any of the grade levels listed, state your estimate of grade level in the space marked "Other ...."
4. Please use *only* your personal judgment in estimating the grade level of each sample.
5. Return the samples in the enclosed self-addressed envelope.

THANK YOU

IN THE SPACE BELOW THE SAMPLE, PLEASE CHECK YOUR ESTIMATE OF ITS GRADE LEVEL OF DIFFICULTY

If you have ever tried to play a violin or if you have watched someone playing a violin, you know that this instrument also has thick strings and thin strings. Again, the thicker strings give the lower pitched tones. Also, the pegs on a violin allow the player to tighten or loosen the strings so as to tune the instrument properly. When playing a tune, the violinist presses his fingers down upon the strings at different points. In this way, he changes the length of string, producing the different pitched tones needed for the melody.

You may be interested in making a piano.

3 ______	6 ______
3½ ______	6½ ______
4 ______	7 ______
4½ ______	7½ ______
5 ______	8 ______
5½ ______	8½ ______
	Other ______

No. 15C

Of the ninety-two sets of samples sent out to reading experts, seventy-four were returned.

TABULATION AND ANALYSIS OF THE DATA

In order to compare the consistency of the measurements of grade level of reading

TABLE I

FREQUENCY DISTRIBUION BY GRADE LEVEL OF EVALUATIONS OF READING DIFFICULTY

Grade Levels of Difference Between Highest and Lowest Measurement	Number of Cases of Difference									
	Grade 4		Grade 5		Grade 6		Grade 7		Grade 8	
	Formulas	Experts	Formulas	Experts	Formulas	Experts	Formulas	Experts	Formulas	Experts
0.0	3	0	2	0	4	0	7	0	4	0
0.5	8	0	8	0	4	0	14	0	16	0
1.0	9	1	11	0	11	1	20	0	24	1
1.5	3	1	1	4	3	1	5	5	10	1
2.0	2	3	1	3	1	3	6	8	7	8
2.5	0	10	2	3	1	3	2	4	2	6
3.0	0	6	0	5	1	5	1	15	0	18
3.5	0	0	0	2	0	3	2	11	1	7
4.0	0	2	0	6	0	5	1	10	0	14
4.5	0	1	0	1	0	2	1	5	0	8
5.0	0	1	0	1	0	2	0	0	0	0
5.5	0	0	0	0	0	0	0	2	0	0

difficulty of the samples as determined by the three readibility formulas, with that of the evaluations made by the reading experts the data were tabulated and analyzed. Table I that follows contains a frequency distribution of the grade levels of differences between the highest and lowest measurements obtained with the readability formulas, and between the highest and lowest estimates made by the reading experts. The data are tabulated according to the grade levels for which the textbooks, from which the samples were taken, are designed:

Table II contains the data found in Table I without regard for grade level.

TABLE II

FREQUENCY DISTRIBUTION OF ALL EVALUATION MADE

Difference Between Highest and Lowest Evaluation of Reading Difficulty	Number of Cases with Formulas	Number of Cases with Estimates of Reading Experts
0.0	20	0
0.5	49	0
1.0	75	3
1.5	24	12
2.0	18	25
2.5	6	26
3.0	2	51
3.5	3	22
4.0	1	37
4.5	1	17
5.0	0	4
5.5	0	2

CONCLUSIONS

In so far as the techniques employed in this study may be valid, the following conclusions seem defensible:

1. The data obtained in this study indicate that there is a great difference between the consistency with which the readability formulas evaluate the grade level of reading difficulty of the samples, and the consistency with which the reading experts evaluate the grade level of reading difficulty of the samples.

2. In none of the one hundred and ninety-nine samples did the reading experts agree completely with respect to the grade level of difficulty. However, in twenty of the samples the readability formulas gave the same measurement of reading difficulty.

3. In forty-nine of the sample passages the measurements made with the readability formulas differed by only .5 of a grade level. In none of the samples did the estimates of the reading experts differ by only .5 of a grade level.

4. In the measurement of seventy-five sample passages, the measurements made with the readability formulas differed by one grade level. In three of the samples evaluated, the reading experts differed in estimates of reading difficulty by one grade level.

5. In the measurement of twenty-four sample passages, the readability formulas differed in grade level evaluation by 1.5 grade levels. The reading experts differed in their estimates by 1.5 grade levels one twelve sample passages.

6. In the evaluation of eighteen sample passages the readability formulas differed by two grade levels, as compared with twenty-five samples in which the estimates of reading experts differed by two grade levels.

7. In the measurement of six samples, the readability formulas varied by 2.5 grade levels. In the estimates of twenty-six samples, the reading experts differed by 2.5 grade levels.

8. In only two of the samples measured by the readability formulas did the evaluations differ by three grade levels. However, the estimates of reading difficulty varied by three grade levels in fifty-one samples estimated by reading experts.

9. The measurement of grade level of difficulty by readability formulas differed by 3.5 grade levels in three samples. The estimates of grade level of difficulty by reading experts differed by 3.5 grade levels in twenty-two samples.

10. The measurements by formulas differed by four grade levels in one sample analyzed, as compared with thirty-seven samples in which the estimates of reading experts differed by four grade levels.

11. The measurements by formulas differed by 4.5 grade levels in one sample. The estimates of reading experts differed by 4.5 grade levels in seventeen samples.

12. In none of the samples measured did the readability formulas differ by five grade levels. However, the estimates of reading experts differed by five grade levels in four samples.

13. In none of the samples analyzed did the readability formulas differ in measurement by 5.5 grade levels. In two of the samples the estimates of the reading experts varied by 5.5 grade levels.

14. The data obtained by the study indicate that readability formulas measure grade levels of reading difficulty of science materials with much more consistency than reading experts estimate grade levels of reading difficulty.

15. The data reveal no great difference in the consistency of measurement by the readability formulas at various grade levels. However, the measurements were slightly less consistent at the seventh- and eighth-grade levels.

16. The estimates of the reading experts were most consistent at the fourth-grade level and least consistent at the seventh- and eighth-grade levels.

17. The evaluations made for higher level materials by both formulas and experts tend to be somewhat less consistent than those for lower level materials.

18. It is apparent that the statement made by Dr. Betts that any good teacher can tell the difficulty of reading materials by examining them is not supported by the data obtained in this study. Rather, the data reveal that even those teachers who are considered *reading experts* are very inconsistent in their estimates of reading difficulty.

RECOMMENDATIONS

In so far as the conclusions of this study are valid, the following recommendations seem defensible:

1. In view of the need which has been expressed for evalaution of reading materials as to grade level of difficulty, and in view of the lack of consistency in the estimates of grade level of difficulty of reading materials by reading experts, it seems desirable that a more reliable technique should be used to evaluate materials as to their suitability with respect to this criterion. It must be remembered that the estimates of grade level of difficulty used in this study were the estimates by reading experts in large school systems, not the estimates of average classroom teachers. Teachers might not do as well. It appears, therefore, that all teachers should have some method of evaluating materials as to reading difficulty which is more objective than their estimates.

2. On the basis of the data presented in this study, it is suggested that a teacher use the evaluation of grade level of difficulty as determined by a readability formula, in combination with her judgment as to content, organization, and interest level, in the selection of reading materials for classroom use.

3. It is suggested further that the teacher be trained more adequately in the techniques of evaluating materials with respect to their suitability for use. Much emphasis has been placed on how children should learn to read, but too little on what children should read. Since the selection of materials seems to be of great importance, and since this area appears to be neglected, it is suggested that more time in the training of teachers should be devoted to selection and evaluation of reading materials.

THE DEVELOPMENT AND EVALUATION OF AN IN-SERVICE EDUCATION PROGRAM IN ELEMENTARY SCHOOL SCIENCE *

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THE quality and quantity of science instruction at the elementary school level has been a matter of concern to those interested in science education for many years. Science educators and most classroom teachers are constantly seeking methods for the improvement of science instruction in the elementary schools.

The literature pertaining to science education in the elementary school indicates that many teachers do not have sufficient background in academic science, or they do not know how to present science to children. Many teachers consider themselves unprepared to teach science, or lack confidence in their ability to teach science. Zim has stated that: "Most teachers of primary grades are untrained in science. Some of them are afraid of things scientific, . . ." [1] Consequently, there are many classrooms that do not have a creative science program, or that do not consider science at all. Blough [2] is of the opinion that teachers in the elementary school seem generally unprepared to do the kind of science teaching they would like to do. In general he believes that teachers have an inadequate subject matter background and that their methods of teaching science are also weak.

The literature makes clear the need for programs that will assist classroom teachers to improve their instruction in science. In a summary of recent research in elementary science, Buck and Mallinson wrote: ". . . before elementary-science-education can improve, changes must be made in the training programs for teachers. Meanwhile, steps must be taken to give in-service training to the present teachers." [3] Croxton [4] indicated that research is needed with regard to in-service education of teachers in the science area.

In-service programs have been suggested and used as a means of improving science instruction in several instances. The Forty-Sixth Yearbook of the National Society for the Study of Education states that: "Every school system should have a program of in-service education in science in operation." [5] Teachers, as well as science educators, are aware of the advantages of in-service programs. Curtis [6] inquired of 569

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[1] Herbert S. Zim, *This is Science.* The Association for Childhood Education, Washington, D. C., 1945, p. 8.

[2] Glenn O. Blough. "Elementary School Science—Implications for High Schools," *National Association of Secondary-School Principals,* Bulletin 37 (January, 1953), 38–42.

[3] Jacqueline V. Buck and George G. Mallinson, "Some Implications of Recent Research in the Teaching of Science at the Elementary-School Level," *Science Education,* 38 (February, 1954), 99.

[4] W. C. Croxton, "Needed Research in the Teaching of Elementary Science with Every Teacher a Researcher," *Science Education,* 39 (February, 1955), 21.

[5] National Society for the Study of Education. *Science Education in American Schools.* Forty-Sixth Yearbook, Part I. University of Chicago Press, Chicago, 1947. p. 135.

[6] William C. Curtis, "Improvement of Instruction in Elementary Science," *Science Education,* 34 (October, 1950), 234–242.

elementary teachers in New York State concerning their needs in the science area. Most of the teachers felt the need for in-service training, and for a professionalized course in materials and methods to be given in college. One of the findings from a study made by Boyer [7] was that elementary teachers who had an "adequate" science program had participated in intensive, if occasional, in-service workshops in science to augment their overall science-education planning. Boyer recommended that elementary school administrators should continue to seek the means to develop, in their own schools, better in-service science training.

Recent investigations have shown that in-service education programs can be effective in improving science instruction in the elementary school. Mork [8] worked intensively throughout a school year with three volunteer fifth grade teachers and one volunteer sixth grade teacher in an in-service science program. The pupils of these teachers were tested in science and the results compared with control pupils. Mork concluded that the experimental teachers, through the given test results of their pupils, showed an increased effectiveness in instruction which was associated with the in-service science education program.

Galeno [9] conducted an investigation with regard to workshops designed to improve the science programs for elementary grades. One aspect of the workshops was the development of functional guides which proved to be useful to the teachers in their classes.

[7] Donald A. Boyer, "A Comparative Study of the Science Achievement of Pupils in Elementary Schools," *Science Education*, 39 (February, 1955), 3–12.

[8] Gordon M. A. Mork, "Effects of an In-Service Teacher Training Program on Pupil Outcomes in Fifth and Sixth Grade Science." Unpublished Doctor's Dissertation, University of Minnesota, 1953, *Dissertation Abstracts*, 13 (1953), 522–523.

[9] Ramona T. Galeno, "The Cooperative Development of an Elementary Science Program in the San Francisco Unified School District." Unpublished Doctor's Dissertation, Stanford University, 1954, *Dissertation Abstracts*, 14 (1954) 1630–1631.

INITIATING AN IN-SERVICE EDUCATION PROGRAM IN SCIENCE

As a result of his experiences, the investigator became interested in developing an in-service education program in elementary school science, and the cooperation of the Administration of the Topeka Public Schools was obtained to conduct such an experiment. The problem of this investigation was to conduct and evaluate an in-service program in elementary science education for elementary school teachers. The objectives, concepts, methods, and materials of science appropriate to the elementary school were presented. The major problem had two sub-problems:

1. To develop and conduct a series of meetings designed to provide information and assistance with the various aspects of elementary school science.
2. To evaluate and appraise, through the use of appropriate techniques, the in-service program.

The evaluation included: (a) the measurement and comparison of pupil achievement of experimental and control groups of fourth, fifth and sixth grade pupils, and (b) an evaluation of the program by principals and the participating teachers (experimental group) to discover the merits and weaknesses of the in-service program, particularly for its significance for possible future use for elementary school teachers.

The original plan was to have teachers from grades two through six volunteer to participate in the in-service program. However, the administrators of the Topeka Public Schools thought that the in-service program would be more typical of those conducted in the school system, if teachers from all grades could volunteer to participate. It should be emphasized that the in-service program was developed and conducted under field conditions and cannot be considered an "ideal" program, but an actual practical program. It was felt that a highly structured and precisely controlled experiment could not be made without at the same time making a somewhat artificial

situation. The possible alternatives seemed to favor the choice made.

Beginning in September, 1955, twenty-six teachers of kindergarten through grade six participated, on a voluntary basis, in a series of eleven in-service meetings. The teachers were from 13 of the 23 elementary schools of the Topeka Public School system. The meetings were held twice each month, October through January, and once each month, February through May. The time of the meetings was from 4:30 until 6:30 P.M.

Since the teachers were from all grades, the content of the meetings was quite general. However, an effort was made to meet the needs of the individual teachers. The teachers were not required to make reports or other outside preparations. It was hoped that ideas and information obtained from the in-service meetings would be applied to the individual classroom situation. The general plan for each meeting was to consider one or two topics, present demonstrations and experiments, and provide science materials, equipment, and reference sources. At the first four meetings a topic such as "the objectives for science teaching in the elementary school," and "the integration of science with other areas of the curriculum," was discussed. In addition some specific science content topic was considered, such as "Air and Weather," "Magnets and Electricity," and "Conservation." An outline or general information concerning each topic was mimeographed and distributed to the teachers.

Appropriate demonstrations were presented at each meeting, from seed and rock collections to microscopic preparations showing algae or insect wings. Experiments were performed at each meeting which could also be done in a classroom by children or by the teacher. The materials for the demonstration and experiments were always simple and easily obtainable. It was emphasized that the materials for science instruction need not be elaborate, and that most of the materials are available in the school building or can be brought in by pupils. The investigator performed most of the experiments. However, individual teachers performed a few experiments and it was often possible to have sufficient materials so that a group of teachers could work together on certain experiments.

The reference materials were textbooks for children, teachers guides to accompany the textbooks, various science books written for children, science books on methods and materials for elementary school teachers, books of science experiments and information, and selected periodical literature. The reference materials could be borrowed and were used extensively by the teachers.

SCIENCE TESTING PROGRAM

In order to determine whether or not the in-service education program would effect the achievement in science of the pupils of the participating teachers, a testing program was conducted. A suitable pencil and paper test in science was not available for all elementary grades, hence, only fourth; fifth and sixth grade pupils were tested.

SELECTION OF CONTROL TEACHERS AND COMPARISON WITH THE EXPERIMENTAL TEACHERS

Sixteen of the teachers participating in the in-service program of grades four, five and six gave a science test to their pupils in October, and repeated the same test in April. The teachers and classes were identified as the experimental teachers and classes. However, only ten of these classes were compared with control classes in the final analysis of data.

For purposes of control it was necessary to identify teachers and classes which were as nearly comparable as possible to the experimental teachers and classes. The selection of the control teachers and classes was made in conference with the Consultant for Elementary Education and the Director of Curriculum of the Topeka Public Schools.

The factors considered in selecting the control teachers and classes were: (1) school facilities and general socio-economic status of the area served; (2) teaching ability; (3) teaching experience; and (4) the college background in science. The teaching experience and science background information was obtained from records available in the Board of Education office. Obviously all of the experimental teachers could not be matched perfectly with control teachers. However, the choices that were made were considered reasonably accurate when all of the factors were taken into consideration.

Some of the control teachers were from the same schools as the experimental teacher with whom they were matched; others were from comparable schools. Eighteen teachers agreed to act as control teachers and administer the science test to their pupils. Only ten of the classes of these teachers were used in the final comparison of data.

Tests Used in the Study. The science test that was administered to the pupils was developed by Dr. Gordon M. A. Mork[10] who granted permission to use the test. The test has five parts, but on the suggestion of Dr. Mork, Test I was not used. There are a total of 127 objective questions on the science test as used. Included in the test are 40 items involving content drawn from biology, and 67 items from the physical sciences.

Intelligence quotients were obtained from the official records. The intelligence test scores for the fourth and fifth grade pupils were from tests given in the third grade; the test used was the *California Short-Form Test of Mental Maturity*.[11] The intelligence scores of the sixth grade pupils were from tests given during the school year of 1955–1956; the test used was the *Otis Self-Administering Test of Mental Ability*.[12] Intelligence quotients were not available for all the pupils tested in science, and these pupils were not included in the analysis of data.

The Sample. The pupils of the fourth, fifth and sixth grade classes who were tested in science, and from whom inferences are drawn in this study, were the pupils of the teachers of these respective grades who participated in the in-service program, and the pupils of the matched control teachers. Pupils for whom there were incomplete test data were not used in the analysis. There are 23 elementary schools in the Topeka Public School system; pupils of 14 of these schools were tested in science. There were 3,121 pupils enrolled in grades four, five and six of the 23 schools; approximately 600 of these pupils were tested in science, including the pupils of both the experimental and control groups of teachers. However, there were complete test data for only 405 pupils. Of these, 210 were boys and 195 were girls. There were 87 fourth grade pupils of the experimental teachers and 78 fourth grade control pupils; the fifth grade experimental pupils numbered 128, and there were 112 fifth grade control pupils. Sixth grade classes were included in the testing program, but for reasons beyond the control of the investigator, only one experimental class completed the testing program. The post-test scores of the experimental class and the matched control class were not normally distributed; therefore, a comparison of sixth grade classes is not included in this study.

STATISTICAL ANALYSIS OF THE DATA

Reasonable normality of test data is an assumption that underlies the statistical technique of analysis of variance and covariance used in this study. It was neces-

[10] Gordon M. A. Mork. "Effects of An In-Service Teacher Training Program on Pupil Outcomes in Fifth and Sixth Grade Science." Unpublished Doctoral Dissertation, University of Minnesota, 1953, pp. 211–225.

[11] *California Short-Form Test of Mental Maturity.* Primary Grades, 1–2–3, S-Form. California Test Bureau, Los Angeles, California, 1953.

[12] *Otis Self-Administering Tests of Mental Ability.* Intermediate Examination, Form C, Grades 4–9. World Book Company, Yonkers-on-Hudson, New York, 1928.

sary to determine whether or not the post-test science scores were normally distributed. The Chi-square technique was used to determine normality of the distribution of post-test scores. The formula applied in this procedure was:

$$\text{Chi-square} = \Sigma \frac{(O - E)^2}{E}$$

in which O is the observed frequency of scores and E is the expected frequency. The hypothesis that the distribution of scores was normally distributed was accepted or rejected below the five per cent level of significance.

The scores obtained from the test for all of the pupils, by grade and for experimental and control groups, were tabulated and the Chi-square values obtained. All of the Chi-square values were below the five per cent level of significance; the hypothesis that the distribution of scores was reasonably normal was accepted.

Analysis of Data. In planning the pupil-testing portion of the in-service program the application of analysis of variance and covariance was considered to be the appropriate statistical tool. The hypothesis to be tested was that there was no difference in mean pupil achievement between pupils whose teachers participated in the in-service meetings and those whose teachers did not participate, when the effects of intelligence quotients and pre-test science scores were held constant.

The data for the experimental classes of each grade and for the control classes of each grade were pooled. Before the data could be pooled, two assumptions had to be satisfied. These assumptions were: (1) homogeneity of variances, and (2) homogeneity of means. The assumptions were tested for all of the classes within each grade group, using the post-test scores. The first assumption was tested by using the L-test on the "sum of squares within groups," and the second assumption was tested by using the F-test, in which F was found by dividing the mean square between groups by the mean square within groups.

These were five fourth grade experimental classes tested for the assumptions for pooling; one of these classes did not meet the assumption for homogeneity of means and was not used in the subsequent analysis. The remaining four classes met the assumptions for pooling when the L-test and F-test were again applied. The four classes of the control teachers, who were matched with the experimental fourth grade teachers and classes, met the assumptions for pooling.

Six experimental fifth grade classes met the assumptions for pooling. However, it was necessary to divide the six classes into two groups of three classes each, designated Experimental group A and Experimental group B. The control fifth grade classes that were matched with the experimental classes, were divided into two groups of three classes each, Control group A and Control group B, and met the assumptions for pooling. As a matter of interest the means of the intelligence quotients of the two groups of experimental and control classes were compared. The mean of the intelligence quotients for experimental group A was 107, and for control group A it was 110; the mean of the experimental group B was 94.7, and of the control group B it was 101.5.

Two additional assumptions had to be met before the analysis of variance and covariance could be applied. These assumptions were: (1) homogeneity of variances using the post-test scores for the pooled groups, and (2) homogeneity of regression within groups for the pooled groups. These assumptions were tested by means of the L-test. The first assumption was tested by using the "sum of squares within groups" using the post-test scores only. The second assumption was tested by using an adjusted "sums of squares within groups" using data from intelligence quotients, pre-test scores, and post-test scores. An L value of .982 was obtained for the test of homogeneity of variances for the pooled fourth grade groups, experi-

mental and control. This value was not significant at the 5 per cent level with k equal to 2 and a harmonic mean of 82.3. The L value for the test of homogeneity of regression for these groups was .997, which is also not significant at the 5 per cent level.

The test for homogeneity of variances for pooled groups A, experimental and control, of the fifth grade classes gave an L value of .998, and the test for homogeneity of regression gave an L value of .987. Both of these values are non-significant at the 5 per cent level with k equal to 2 and a harmonic mean of 65.8. The test for homogeneity of variances for the pooled fifth grade experimental and control groups B resulted in an L value of .943, which is not significant at the 1 per cent level with k equal to 2 and a harmonic mean of 53. The test for homogeneity of regression gave an L value of .996 which is not significant at the 5 per cent level.

It was concluded that the three sets of pooled classes, one fourth grade and two fifth grade, experimental and control groups, met the assumptions for applying the analysis of variance and covariance. The next step was the calculation of the F ratios using the adjusted sums of squares for analysis of variance and covariance; the results are shown in Tables I, II and III.

The null hypothesis was rejected, with regard to the fourth grade classes and the two groups of fifth grade classes, and it was concluded that differences in achievement existed between the experimental and control groups holding intelligence quotients and pre-test scores constant.

TABLE I

TEST OF SIGNIFICANCE OF PARTICIPATION IN IN-SERVICE TRAINING ON SCIENCE ACHIEVEMENT OF FOURTH GRADE CLASSES

Source of Variation	d.f.	Adjusted Sum of Squares	Mean Square	F	Probability
Within groups	161	8824.7	54.8		
Between groups	1	719.4	719.4	13.12	P < .01
Total	162	9544.1			

TABLE II

TEST OF SIGNIFICANCE OF PARTICIPATION IN IN-SERVICE TRAINING ON SCIENCE ACHIEVEMENT OF GROUP A FIFTH GRADE CLASSES

Source of Variation	d.f.	Adjusted Sum of Squares	Mean Square	F	Probability
Within groups	130	5791.8	44.6		
Between groups	1	1098.6	1098.6	24.66	P < .10
Total	131	6890.4			

TABLE III

TEST OF SIGNIFICANCE OF PARTICIPATION IN IN-SERVICE TRAINING ON SCIENCE ACHIEVEMENT OF GROUP B FIFTH GRADE CLASSES

Source of Variation	d.f.	Adjusted Sum of Squares	Mean Square	F	Probability
Within groups	102	4434.07	43.47		
Between groups	1	310.62	310.62	7.15	P < .01
Total	103	4744.69			

Adjusted means of the post-test scores were computed for the experimental and control groups for each grade in which the null hypothesis had been rejected. The adjusted mean for the pooled experimental fourth grade classes was 66.15 and for the control classes it was 62.90. The adjusted mean for the experimental group A fifth grade classes was 76.18 and for the control group A it was 70.61. The adjusted means for the experimental group B classes was 62.10 and for the control classes it was 60.08.

It was concluded that, on the average, the fourth and fifth grade pupils of the teachers participating in the in-service program achieved more on the post-test in science than the control pupils, holding intelligence quotients and pre-test scores constant.

NON-STATISTICAL EVALUATION OF THE IN-SERVICE MEETINGS

The participating teachers made a written anonymous evaluation of the in-service program at the final meeting. The teachers were asked to comment on various aspects of the meetings relative to such items as the coverage of the objectives for teaching science, the content of science, the experiments and demonstrations, equipment, reference materials, and general comments they cared to make.

Twenty-four of the 26 participating teachers completed the evaluation. One of the evaluation items was: "have your method(s) of teaching science change, and if so, how?" Nineteen of the 24 teachers indicated that their method had changed. In replying to "how" they had changed, the most frequent responses were that more experiments and demonstrations had been performed, and there had been greater interest and pupil participation. In response to the evaluation item relative to the best features or opportunities of the program, eleven of the teachers indicated that the experiments, demonstrations, and materials were among the best features. In response to "what defects and weaknesses were apparent," ten of the teachers wrote that they were too tired; two teachers thought that the meetings were too general, and one teacher was of the opinion that the meetings were "geared" to the upper grades. Eleven of the teachers omitted this item. The final item asked for additional comments. Eighteen teachers wrote that the meetings had been of practical value and they had gained many helpful ideas which had resulted in better teaching. Six teachers did not respond to this item.

As a result of the evalaution it seemed reasonable to conclude that the in-service program had been effective in enhancing the teaching of science in the classrooms of the teachers who participated in the in-service meetings.

Appraisal of the In-Service Program by Principals. Teachers from thirteen elementary schools participated in the in-service program. A letter was sent to the principals of each of these schools requesting comments relative to the science program of the teacher, or teachers, in the school who had participated in the meetings. Twelve of the principals replied; one principal, in whose school there was one participating teacher, did not reply.

All of the principals who replied were in accord that the in-service program had resulted in constructive changes in the teaching of science on the part of the participating teachers. The principals indicated that the teachers had gained insight into the importance of science in the elementary school, and as a consequence had enjoyed a more creative science program.

SUMMARY AND CONCLUSIONS

The problem of this investigation was the development and evaluation of an in-service education program in elementary school science. Twenty-six teachers of kindergarten through grade six participated in the program on a voluntary basis. Eleven meetings were held during the school year. The basic questions involved concerned the

effects of the in-service program on the improvement of science instruction in the classrooms of the participating teachers. In order to evaluate the program, a pre- and post-test in science was administered to ten experimental classes of fourth and fifth grade pupils whose teachers participated in the in-service meetings. These classes were compared with ten control classes whose teachers were matched with the teachers of the experimental classes. The participating teachers and principals in the cooperating schools made a written evaluation of the in-service program.

On the basis of the techniques of statistical analysis used in this study, and within the limitations imposed by the tests employed, it may be concluded that:

1. The fourth grade experimental classes achieved more on the post-test in science holding intelligence quotients and pre-test scores constant, than the control fourth grade classes.

2. The fifth grade classes were divided into two groups of three classes each. One group was designated as Group A and the other as Group B. Differences in achievement existed between the experimental and control groups as measured, and these differences were in favor of the classes of the experimental teachers.

No conclusions based on the testing program could be drawn relative to the achievement in science on the part of the pupils of the teachers of kindergarten through grade three.

The teachers who participated in the in-service program, and their principals, considered the program of practical value in assisting the teachers to improve the science instruction in their classrooms.

The above conclusions should be tempered by the fact that the teachers participated on a voluntary basis, which would indicate that they were interested in professional growth in the area of science teaching. It would also indicate that these teachers recognized the need for assistance with their science programs.

The results of this study provide evidence that the effects of an in-service program can result in greater achievement in science on the part of some pupils.

Furthermore, this study indicates that teachers who are interested can profit from participating in in-service education programs to the extent that they gain ideas that they believe to be of value in improving the quality of the teaching of science in their classrooms.

Since the consensus of qualified opinion is that many teachers do not have an adequate science program, the results of this study would suggest that participation in in-service programs in science should be encouraged on a wider scale.

SCIENCE PLUS SOCIAL STUDIES EQUALS UNDERSTANDING

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In a democracy based upon technology, it has been said, the only truly "social sciences," i.e., those which undergird society, are the physical and biological sciences. We cannot, it is presumed, have a full understanding of economics, sociology, history of politics of a democracy unless we understand the basic scientific principles upon which its industries are based. There is much to be said for this viewpoint, from the place where the science teacher stands. There is also much to be said for this viewpoint from the place where the elementary school teacher stands, amidst a variety of studies, all of which she directs.

The atomic scientists—atomic physicists, atomic biologists, and others connected with nuclear fission—have constantly reiterated

to our newspaper public the importance of a general understanding of science for the layman. Magazines of general circulation have written for their readers "primers of atomic energy" so that fathers and mothers whose physics was long ago and far away can be "up-to-date" from the standard of "what the intelligent parent should know about the atom and nuclear fission and fusion." More and more the "general education" science courses at high school and college level have brought to students in intermediate and higher education an overview of the facts.

But more than this is necessary. The project in community education, *Operation Atomic Vision,* issued by the National Association of Secondary School Principals, attempts to get at the integration of science and social studies at the high school level in one area. Yet far more than this is needed, if we are to achieve, in "an intelligent citizenry" the kind of working knowledge, about all types of science as they impinge upon the social scene, which is required for rational behavior.

The movement toward general education seems to be the answer to the problem posed us in education by those in government who decry the ignorance of the adult world in matters scientific. And, if general education is the answer, we must examine rather carefully what is meant by "general" in order that we may not be guilty of illustrating the ancient truism that "a little learning is a dangerous thing." The implications of "little learnings" are so clear as to need no explanation.

To date, general education, especially in the field of science, has seemed to be the private preserve of the secondary school and the general (or junior) college. If, however, the apex of the inverted cone of "general education" were to rest within the First Grade curriculum, with increasing scope in each subsequent grade, it seems extremely probable to the writer that the work of all those engaged at higher levels might be made easier and more fruitful. A good foundation in the primary and intermediate grades would provide for deeper study and greater ramifications at the secondary school level.

Part of the hesitancy of the primary and intermediate grade teachers at introducing science at much more than the "nature study" level lies in the poor preparation that they have had in their professional preparatory curriculum. Colleges concerned with teacher education are quite aware of this and are beginning to do something about it. Much of the "methods course" in science in many colleges has been a combination of studying science and examining materials and methods of presentation.

Further, part of the hesitancy of such teachers also arises from the related factor that social studies is, for most elementary school teachers who also have to teach science, a more interesting and meaningful area in their own experience. Teachers are notorious travelers, when salaries permit. Geography and history have some meaning to them, whereas all too often science does not.

What then would be more simple than use of the two fields together? Call it what you will—core, fused, integrated, or whatnot—such a merging of two fields should make the teacher more at home within her subject, should give the student a broader, less segmented view of the whole, and should make the learning environment more productive of results which will be a foundation for those in later years who now deprecate the work of their lower-grade colleagues.

Two or three examples, culled from the writer's experience with student teachers, indicate what may be done. One Fourth Grade teacher was about to embark upon a study of the history and geography of Mexico and Central America, in the social studies area. Examination of the science textbook indicated very few points at which there would be any reinforcement of learning through social reference. Several new projects in science were, therefore, worked

out. One, on hurricanes and tropical storms, proved to be of such excellent value that others were tried. The economic botany of tropical rain forests, equivalence of altitude and latitude, and studies of convection currents in warming or cooling liquids all proved points of departure which made both the science and social studies more valuable. The greatest problem was finding material at appropriate reading-ability level to satisfy the students' demands.

In another instance some primary children were studying the life of the pioneers. Since an activity approach was being used, much science was worked into the area by means of study of (a) methods of preserving food used by pioneers (with actual experiments in smoking meat, drying apple curls and pumpkin rings, etc.), (b) methods of making building materials (with actual experiments in cutting turf blocks, making adobe blocks, and making mortar and mud pastes for caulking), and (c) methods of gaining mechanical advantage in erection of log houses. These were really scientific in approach, since generalizations appropriate to the age-level of the children were drawn.

There is no denial that such projects require more teacher-work than use of a text-book in the science series. Too often, however, the science textbook in the hands of the unskilled or indifferent teacher is heir to all the evils of the workbook used improperly. It is necessary for the teacher to become chief learner in a group of learners, but since that is good teaching (as well as good in-service training), competent teachers should welcome the prospect.

Frequently a group of teachers, working together in some teacher education extension course, can prepare needed materials. Students in the writer's classes have prepared a variety of source-books for use in this manner. These would have little value outside the immediate area in which they were and are used, for Ohio river barge building, river stage gauging and the like are of regional interest only, from the standpoint of direct science experience. What these teachers have done, others can do, however, and the use of trained science personnel from the secondary and higher education levels, acting as consultants as they do in Illinois and elsewhere, gives the elementary school teacher much help.

It cannot be expected that the merging of these two fields can be done at all times, nor is that even worthwhile as a goal. But certainly within a school system the study of magnets might be shifted one year to coincide with a study of the iron and steel industry. Or the use of weather charts and their construction could very well be deferred until the study of the functions of the federal government would make it more meaningful in the total picture.

It has been said of the field of science that if we declared a moratorium on all research for ten years, and merely cross-indexed all that we now have found, and discovered new interrelations in already known facts, we would be amply repaid for the effort. The same thing might be said of the material for teaching science as a function of every-day living. Too few elementary school teachers know what is available, where it can be obtained, and how it can be adapted for their use. Those of us who are or have been full-time science teachers should devote some of our time to helping our elementary school colleagues. My own efforts have been rewarded with excellent results, not only in teaching materials, but in rapport. That is something the schools of America need if they are to achieve the integration and articulation within themselves which they are striving to achieve in the curriculum.

A WORKSHOP IN TEACHING ELEMENTARY SCIENCE: AN IN-SERVICE TRAINING PROGRAM FOR TEACHERS *

Clyde M. Brown
Southern Illinois University, Carbondale, Illinois

Teachers in the elementary schools have repeatedly expressed the opinion that they were inadequately trained to teach the kind of science programs they felt were needed by their pupils. Their feelings of inadequacy may be an indictment of the college preparation in science which they have had. A program should be especially organized to meet their needs rather than permitting the usual general education science requirements for graduation to complete their science experiences. There is a need for experiences in the type of science principles and generalizations which they will be called upon to present to and interpret for the pupils in our elementary schools. A broad overview of the interrelationships of the whole science field both physical and biological, is necessary not just a few specialized experiences in chemistry, physics, zoology or botany.

An examination of the many good elementary science textbooks indicates the rich background which science educators wish to bestow upon the pupils of our schools. Parents, administrators, and teachers, too, aspire to give this training but, because of the ease with which they can get "over their heads" due to their limited understandings and training, teachers avoid or slight the sciences and have a guilty feeling for this neglect.

Teachers are not happy with the conditions that exist and when they find something that they hope will help them to feel more comfortable and adequate in their science teaching, they spread the news to their colleagues. From the acceptance by the teachers of Southern Illinois of the Elementary Science Workshop to be described here, the activities and experiences have met to some degree their needs. They have gained confidence in themselves and in their ability to handle science and science materials, and a willingness to try out the ideas with the understanding that they can learn with their pupils.

In science education classes taught prior to the organization of the Workshop, in-service teachers listed problems which they faced in their teaching. The combined list was broad and had many specific problems peculiar to particular school situations. Analysis of the total group of problems presented by some three hundred teachers showed four major problems characteristic of most of them. These may be listed, not necessarily in rank-order, as:

1—lack of *Space*—for demonstrations and experiments, for display, and for storage;
2—lack of *Time*—to fit science into a curriculum already bursting at the seams;
3—lack of *Materials*—to adequately demonstrate the activities suggested or desirable to be carried out;
4—lack of adequate *Background*—to handle the science materials and the pupil questions aggravated by the science experiences.

After repeatedly meeting these same problems with in-service teachers in methods classes an opportunity to face them head on was provided in the summer of 1953, when a new workshop program was inaugurated in the Graduate School in Southern Illinois University. Free reign in organization was extended by the deans of the Graduate School and the College of Education, and cooperation was offered by members of the Liberal Arts College science departments. A modification of the work-

* Paper presented at the Twenty-ninth Annual Meeting of the National Association for Research in Science Teaching, Hotel Sherman, Chicago, Illinois, April 21, 1956.

shop technique was decided upon as the most feasible approach.

In the organization of the first sessions of the Workshop in Teaching Elementary Science three purposes were laid down around which the program of experiences should be built. The first purpose it was desirable to meet was "to provide science experiences which could enrich the science teaching the next year"; second, "to permit the participants to meet with people who were authorities in the fields of science and science education; and third, "to provide an opportunity for teachers to share experiences concerning their problems and successes in teaching science with others teaching at the same levels."

Two groups of teachers were considered in the planning during that first and subsequent summers. In the first group were those teachers desiring some aid in their science programs but who did not want to or could not afford to spend a full summer in school. For these a sixty-hour program was arranged in two five-day weeks at the first of the summer school with six hours a day (three hours in the morning and three hours in the afternoon) devoted to the program. In the second group were those teachers regularly enrolled in the summer school sessions of the College of Education. For these teachers an afternoon program for four weeks devoting three hours to a day was planned. To economize on staff personnel in the afternoon sessions both groups met together during the first two weeks, and the activities carried out in the morning sessions were either duplicated or equated in the third and fourth weeks so that essentially the same experiences were provided for both groups.

It was decided that the workshop would be held during the summer of 1953 if a minimum of fifteen students enrolled, however, approximately sixty-five had been enrolled before enrollment was closed, and a sufficiently large number were turned away to justify offering a special third section for twenty-five students during the last two weeks of the summer school. Advance enrollment filled the sections during the summers of 1954 and 1955 prior to opening of school, and one off-campus workshop using a modification of the program attracted fifty students.

To one who is schooled in the workshop techniques the program might be criticised as being too highly structured to be called a workshop; however, to meet the needs of teachers with such varied backgrounds and to attempt to find some answers for the four major problems, a structured program seemed desirable. A definite attempt was made to tailor all the experiences provided to the needs of teachers desiring to do a better job of teaching elementary science. Teachers of kindergarten through junior high school were represented among the participants. Each was to consider each of the learning experiences in the light of how it contributed to the specific grade or grades he taught. A diary or day-book type of reporting of activities was made by each teacher after each session. This report of each participant was personalized to the degree that it included a brief summary of his interpretation of what transpired and how the experience could be applied at the grade level in which he taught.

The program included open forum discussions, panel discussions, lectures, demonstrations and field trips. A spirit of comradeship and ease was engendered among the participants, and rapport was developed with the guest speakers.

An agenda for a two weeks session of the workshop is listed below along with a sample evaluation sheet which the participants were asked to complete at the last meeting. All of the activities or personalities included during the three years that the workshop has been held are not listed as some individuals because of other commitments, could not always give their help. The activities included are those which have received high ratings by those who have participated in the workshop.

EDUCATION 441

TWO WEEK ELEMENTARY SCIENCE WORKSHOP

DR. CLYDE M. BROWN, *Coordinator*

Monday — *Morning Session*

9:00–10:00 General Orientation—Dr. Clyde Brown (University School) Coordinator.
"The Place of Science in the Elementary School Curriculum."

10:00–11:00 Analysis of the Status of Science Teaching in the Schools represented in the Workshop.

11:00–12:00 Scope of Science in the Elementary School—Natural Science vs. Nature Study.

Afternoon Session

1:30– 2:30 "Needs for a Physical Science Background by the Elementary Teachers."
Dr. Chalmer Gross (University School, Science)

2:30– 3:30 Needs for Physical Science experiences by the Elementary School Pupils.

3:30– 4:30 Films—"The Scientific Method" and "Science and Superstition."

Tuesday — *Morning Session*

9:00–10:00 Agriculture in the Elementary School Program—Dr. W. E. Keepper (Agriculture Department)

10:00–11:00 Field trip to the demonstration farms of the University Agriculture Department. (Dr. Keepper—leader).

Afternoon Session

1:30– 3:00 Use of Birds and Bird Materials in the Elementary Classroom—Miss Hilda Stein (Zoology Department)

3:00– 4:30 Teaching Science Through Social Studies or vice-versa—Dr. Ross Jean Fligor (University School)

Wednesday — *Morning Session*

9:00–10:45 Conservation of Wildlife and the Use of Wildlife Materials in the Elementary School Program—Dr. Willard Klimstra (Zoology Dept.) Leader.

10:45–11:45 Science Books for Children—Mrs. Marjorie Stull, University School Library—Leader.

Afternoon Session

1:30– 2:30 Introduction to Stream Ecology—Dr. William Lewis (Zoology Dept.) Leader.

2:30– 3:30 Introduction to Plant Ecology—Dr. John W Voigt (Botany Dept.) Leader.

3:30– 4:30 General Problems in Teaching Elementary Science—Open forum discussion by workshop participants.

Thursday — *Morning Session*

9:00–10:00 The Development of Southern Illinois From Pioneer Days—Mr. John Allen (University Museum and Information Service) Leader.

10:00–11:30 Illustrated Lecture on Indian Cultures and Archeological Excavation in Southern Illinois—Mr. Irvin Peithmann (University Museum) Leader.

11:30–11:45 Orientation for afternoon bird hike at Giant City State Park.

Afternoon Session

4:30– 7:30 Bird Field Trip and General Nature Hike in the Giant City State Park—Miss Hilda Stein and Dr. Clyde M. Brown, Leaders.
M. Brown, Leaders.

7:30– 8:30 Operation Ham Sandwich—Picnic Lunch and General Bull Session.

Friday — *Morning Session*

9:00–10:00 Simple Demonstrations in Physical Science That May Be Used In Elementary School Teaching — Dr. Chalmer Gross, Leader.

10:00–11:45 Science Problems Experienced by Workshop Participants—Presentation and general discussion.

Afternoon Session

1:30– 4:30 Zoology Field Trip—Dr. William Lewis, Leader. Purpose—to study the aquatic life of the streams and ponds of Southern Illinois, identification of materials found, methods of preservation, and general care of living materials in the classroom.

Monday — *Morning Session*

General Subject: Fitting Science Into A Busy Program

9:00–10:00 Coordinating Science with the Language Arts and Social Studies—Dr. Mabel Lane Bartlett (Eighth Grade Supervisor, University School).

10:00–11:00 Outdoor Education and its Contributions in the Elementary School Program—Dr. Clarence Stephens (University School Mathematics).

11:00–11:45 Group planning session for the week's activities.

Afternoon Session

1:30– 4:30 Botany Field Trip to Giant City State Park—Dr. John Voigt (Botany Dept.) and Dr. Leon Minckler (Forestry Services) Leaders.
Purposes: To study plant habitats, plant types, plant successions, the forest crops and forest conservation.

Tuesday — *Morning Session*

9:00–11:45 Demonstrations That Worked.
Members of the workshop will exhibit and present plans for demon-

strations which they have found to work advantageously with children in the grades which they teach. Areas which have been suggested are nature study, physics, chemistry, health, biology, conservation, astronomy, and agriculture.

Afternoon Session

1:30– 4:30 "A Do-it yourself program" "Much with Little" Construction of simple apparatus and devices to be used in the elementary school science program—Mr. John Gunderson (Industrial Education Dept.) and Mr. John Plummer (University School Industrial Arts) Leaders.

Wednesday

Morning Session

9:00–10:30 Panel Discussion. Subject: Putting the Community Resources to work in Teaching Elementary Science. Participants to be selected from the workshop membership plus invited consultants—Dr. Margaret Kaeiser (Botany Department) Coordinator.

10:30–11:45 Continuation of Demonstrations That Worked.

Afternoon Session

1:30– 4:30 Earth Science and Land Use—Lecture and Directed Field Trip—Dr. Dalias Price, Leader.

Thursday

Morning Session

9:30–10:30 Audio—Visual Aids and How to Use Them in Teaching in the Elementary School—Mr. Don Ingli and Mr. Gordon K. Butts (Audio-Visual Aids Dept.)

10:30–11:45 Services of the Illinois State Museum Available to the Elementary School Teachers — Mr. Milton Thompson (Illinois State Museum) Leader.

Afternoon Session

1:30– 3:00 Teaching Through Field Trips (An Illustrated Lecture) Mr. Milton Thompson, Leader.

3:00– 4:30 "Platter Party" or Educational Records on Science Topics for the Elementary School.

Friday

Morning Session

9:00–10:00 Sources of Free and Inexpensive Materials to be used in Teaching.

10:00–11:45 Examination of Elementary Science Texts, Reference Books, Source Books, Methods and Guide Books available to the Elementary Teacher.

Afternoon Session

1:30 1. Completion of unfinished business.

2. Summary of the workshop activities by the coordinator.

3. Evaluation of the workshop and recommendations of the participants for changes in future workshops in Teaching of Elementary Science.

NOTE: Among the extra-curricular unlisted activities were a voluntary night meeting for the purpose of studying the stars and a campus field trip to determine the kinds of materials that might be found close at hand in the average school yard.

EDUCATION 441

ELEMENTARY SCIENCE WORKSHOP

EVALUATION

Please check activities on scale. The lower the number, the higher your evaluation point.

Experience 1. General orientation
Evaluate: 1.... 2.... 3.... 4.... 5....

Experience 2. "Needs for a Physical Science Background by the Elementary Teachers." Dr. Chalmer A. Gross
Evaluate: 1.... 2.... 3.... 4.... 5....

Experience 3. Dr. Gross—Films—"The Scientific Method" and "Science and Superstition."
Evaluate: 1.... 2.... 3.... 4.... 5....

Experience 4. Dr. W. E. Keepper—Agriculture in the Elementary School Program
Evaluate: 1.... 2.... 3.... 4.... 5....

Experience 5. Dr. Keepper—Field trip to the demonstration farms of the University Agriculture Department
Evaluate: 1.... 2.... 3.... 4.... 5....

Experience 6. Miss Hilda Stein—Use of Birds and Bird Materials in the Elementary Classroom
Evaluate: 1.... 2.... 3.... 4.... 5....

Experience 7. Dr. Ross Jean Fligor—Teaching Science Through Social Studies or vice-versa
Evaluate: 1.... 2.... 3.... 4.... 5....

Experience 8. Dr. Willard Klimstra—Conservation of Wildlife and the Use of Wildlife Materials in the Elementary School Program
Evaluate: 1.... 2.... 3.... 4.... 5....

Experience 9. Mrs. Marjorie Stull — Science Books for Children
Evaluate: 1.... 2.... 3.... 4.... 5....

Experience 10. Dr. William Lewis—Introduction to Stream Ecology
Evaluate: 1.... 2.... 3.... 4.... 5....

Experience 11. Dr. John W. Voigt—Introduction to Plant Ecology
Evaluate: 1.... 2.... 3.... 4.... 5....

Experience 12. General Problems in Teaching Elementary Science—Open forum discussion by workshop participants
Evaluate: 1.... 2.... 3.... 4.... 5....

Experience 13. Mr. John Allen—The Development of Southern Illinois From Pioneer Days
Evaluate: 1.... 2.... 3.... 4.... 5....

Experience 14. Mr. Irvin Peithmann—Illustrated

Lecture on Indian Cultures and Archeological Excavation in Southern Illinois
Evaluate: 1.... 2.... 3.... 4.... 5....
Experience 15. Miss Hilda Stein and Dr. Clyde M. Brown—Bird and Field Trip and General Nature Hike in the Giant City State Park
Evaluate: 1.... 2.... 3.... 4.... 5....
Experience 16. Operation Ham Sandwich—Picnic Lunch and General Bull Session.
Evaluate: 1.... 2.... 3.... 4.... 5....
Experience 17. Dr. Chalmer Gross — Simple Demonstrations in Physical Science That May Be Used In Elementary School Teaching
Evaluate: 1.... 2.... 3.... 4.... 5....
Experience 18. Science Problems Experienced by Workshop Participants—Presentation and general discussion.
Evaluate: 1.... 2.... 3.... 4.... 5....
Experience 19. Dr. William Lewis — Zoology Field Trip
Evaluate: 1.... 2.... 3.... 4.... 5....
Experience 20. Dr. Mabel Lane Bartlett—Coordinating Science with the Language Arts and Numbers in the Elementary School Program
Experience 21. Dr. Clarence Stephens—Outdoor Education and Its Contributions in the Elementary School
Evaluate: 1.... 2.... 3.... 4.... 5....
Experience 22. Dr. John Voigt—Botany Field Trip to Giant City State Park
Evaluate: 1.... 2.... 3.... 4.... 5....
Experience 23. Demonstrations That Worked by Members of the Workshop
Evaluate: 1.... 2.... 3.... 4.... 5....
Experience 24. Mr. John Gunderson and Mr. John Plummer—"A Do-it yourself program" "Much with Little"
Evaluate: 1.... 2.... 3.... 4.... 5....
Experience 25. Panel Discussion
Evaluate: 1.... 2.... 3.... 4.... 5....
Experience 26. Dr. Dalias Price—Earth Science and Land Use—Lecture and Directed Field Trip
Evaluate: 1.... 2.... 3.... 4.... 5....
Experience 27. Mr. Don Ingli and Mr. Gordon K. Butts—Audio-Visual Aids and How to Use Them in Teaching in the Elementary School
Evaluate: 1.... 2.... 3.... 4.... 5....
Experience 28. Mr. Milton Thompson—Services of the Illinois State Museum Available to the Elementary School Teachers
Evaluate: 1.... 2.... 3.... 4.... 5....
Experience 29. Mr. Milton Thompson—Teaching Through Field Trips
Evaluate: 1.... 2.... 3.... 4.... 5....
Experience 30. "Platter Party" or Educational Records on Science Topics for the Elementary School.
Evaluate: 1.... 2.... 3.... 4.... 5....
Experience 31. Sources of Free and Inexpensive Materials to be used in Teaching.
Evaluate: 1.... 2.... 3.... 4.... 5....
Experience 32. Examination of Elementary Science Texts, Reference Books, Source Books, Methods and Guide Books available to the Elementary Teacher
Evaluate: 1.... 2.... 3.... 4.... 5....

I. What experiences would you like to include in this program that were not offered to you?
II. What activities would you recommend to be deleted in future programs of the workshop?
III. Further comments that might benefit this "workshop" in the future are solicited and may be written on the back of this sheet or at the bottom of the page.

In recognition of the facts that the outlined program was a strenuous one, that the patricipants were principally women many of whom are no longer young, and that Southern Illinois summers were hot—caution was used. In the first session the coordinator was careful to point out that each participant was better aware of his own limitations than any other person and should limit himself accordingly. Many of the offerings were to be considered as opportunities for experiences rather than obligations.

The coordinator acted as interpreter and leavening agent throughout the program striving to see that the materials presented were in keeping with the purposes laid down for the workshop. Those specialists who gave their time and assistance were in sympathy with the program and frequently rephrased their technical terms so that the materials could be translated to the boys and girls to be taught.

In conclusion the coordinator is convinced that the workshop and its reception by the majority of the approximately 250 elementary teachers who have participated thus far in the eight sections offered has been the most satisfying and gratifying experience of the twenty-two years of his teaching experience.

DEVELOPMENT AND STATUS OF TEACHER EDUCATION IN THE FIELD OF SCIENCE FOR THE ELEMENTARY SCHOOL *

WILLIAM D. CHAMBERLAIN
Detroit Public Schools, Detroit, Michigan

INTRODUCTION

A COMPLETE summary of a study of this nature would be impossible in the time allotted and a recitation of the mere statistics involved would be a waste of your time. With your permission I would like to dwell more intently on the implications of the study. I will, however, summarize briefly.

I have with me copies for distribution of the final chapter of the dissertation. This chapter provides a more extensive summary and lists some of the implications of the study. Most of you have received copies previously as contributors.

The importance of science in the elementary school has not been appreciated by the average citizen as it has by the science educator. The lack of science in the elementary school has been a matter of great concern to us. In the roles of teacher of science, teacher of teachers, and as an administrator I was interested in fostering and improving a program of science in the elementary school. The key to the problem seemed to lie in the education of new elementary school teachers and in the re-education of the present teachers. This pattern of thought led to the study which is about to be discussed.

PURPOSES OF THE STUDY

The purposes of the study were: to discover trends in this curriculum area in the pre-service and in-service programs of teacher training institutions; to find the problems that teachers have in carrying on a program of science in the elementary schools; and to suggest some solutions that might be helpful in accelerating the program in the elementary schools.

STRUCTURE OF THE STUDY

In finding a population of colleges with which to work, I found that it was necessary to study college catalogs to locate those institutions which offered courses in elementary school science. Questionnaires were sent to colleges asking about programs and plans for programs. Questionnaires were sent to the membership of the National Association for Research in Science Teaching for help and opinion in surveying trends. Questionnaires were also sent to a select group of teachers who had extensive training in the area of science for the elementary school. These teachers were considered as possessing future leadership qualities by their college instructors. The data from the colleges (catalogs) and questionnaires formed the body of the dissertation.

STUDY OF CATALOGS

The institutions that were included in the study met three criteria: (1) trained elementary school teachers; (2) were accredited by a regional accrediting association, state university, or state department of education; (3) offered a four year course for elementary school teachers. Some 765 colleges were selected on the basis of the above criteria.

The catalogs indicated the following information. More than 60 per cent of the colleges studied were privately supported.

* Paper presented at the Thirtieth Annual Meeting of the National Association for Research in Science Teaching, Claridge Hotel, Atlantic City, New Jersey, February 16, 1957.

Based on research conducted for the Degree of Doctor of Education, Wayne State University, Detroit, Michigan, 1955.

However a greater number of public colleges offered courses in elementary school science than did the private schools. The mean number of required hours of science background for elementary school teachers was 9.04 semester hours with the colleges offering elementary school science averaging slightly better.

The pattern of required science background varied considerably. Some colleges specified a number of hours of science but did not specify which science. Others divided the time between biological sciences and physical sciences but in varying proportions. Comparatively few required that the sciences be laboratory sciences.

Professionalized science courses differed from school to school. The most common offering was a course called materials and/or methods of elementary school science (although the titles were varied) and offering three semester hours of credit. Some ninety colleges listed the area as part of a course which included methods in from two to nine other curriculum areas.

STUDY OF QUESTIONNAIRES

Questionnaires to colleges revealed that most institutions offered only one course or a fraction of a course in elementary school science materials and/or methods. The education faculty, the science department faculty and the state department of education were most instrumental in originating the courses.

Using a base date of 1928, forty colleges out of 448 reported courses already in existence. The year 1936 saw 25 per cent of the schools listing such courses. The 50 per cent mark was achieved in 1944. A total of 75 per cent was reached in 1949 and the last of the 448 colleges listed the date of origination of the course as 1953.

The course in elementary school science methods and/or materials seems to be a stable one as only 0.2 per cent of the colleges plan to combine the course with some other curriculum area (social studies) and the remainder plan to retain or improve the present course offerings.

The questionnaire to the N.A.R.S.T. gave valuable opinion as to the existence and direction of trends. This material is summarized in the accompanying final chapter of the study. Suffice it to say here that such training was considered favorably by the majority of the members answering the questionnaire. Some disagreement was found in trends in development of specialists in science in the elementary school and in elementary school science as a special subject. Practice teaching in science was considered desirable but as a special subject the group was divided.

IN-SERVICE TRENDS

In studying in-service trends, questionnaires to institutions revealed that summer school is still the most common type of in-service training and the only one offered by many institutions. The future plans for in-service training in the area of science in the elementary school resemble the plans for pre-service training, mainly to maintain and improve the courses where offered. Altogether the plans were more nebulous.

The membership of the N.A.R.S.T. was more positive than the colleges in its consideration of in-service programs, feeling that most types of in-service training in elementary school science are on the increase.

PROBLEMS FACED BY TEACHERS, SCHOOL SYSTEMS AND INSTITUTIONS IN IMPLEMENTING OR IMPROVING PROGRAMS OF ELEMENTARY SCHOOL SCIENCE

The selection of a group of teachers was carried out on the following basis. If a group of teachers could be located who had the best available training in science and who had experience in teaching elementary school science, they might be able to analyze their college background. The strengths and weaknesses of their college training might point to problems that would be

amenable to solution. In other words, most problems elementary school science teachers have relate in some way to their training or lack of it. A description of the group of teachers is included in the final chapter of the dissertation.

A brief evalaution of their analyses of their backgrounds indicates that basic courses in all sciences seemed helpful. More field work in biology was indicated. Many wished they had taken entomology and ornithology. Advanced chemistry seemed of doubtful value. Physics courses were considered very valuable. More people wished that they had taken geology and astronomy than any other course. Professional courses in science methods and/or materials as well as non-science professional courses were considered valuable. College workshops, extension courses, demonstration lessons, teacher study groups and publications in science education were considered helpful as an in-service program.

PROBLEMS IN SCHOOL SITUATIONS

Schools scheduled no time for science according to 18 per cent of the teachers, and not enough time according to 24 per cent. One-third did not have sufficient teaching space and one half have storage problems. Half of the teachers purchase part or all of their teaching equipment from their own money. Schools generally permit science experiences or incorporate science experiences in the program. Curricula are generally prepared by the teacher or by the teacher with the help of administrators. Some problems are observed in the acquisition of supplementary science books.

Schools permit or encourage field trips and science clubs. Classes are too large to permit much science activity by individuals or small groups. There is little or no school time to prepare materials or plan.

The administrator varied in his support of the program in the elementary school. Some 25 per cent of the teachers find indifference or antagonism as a problem.

PROBLEMS OF SCHOOL SYSTEMS AND INSTITUTIONS

The questionnaire to the N.A.R.S.T. indicated that the trends in objectives and practices have changed with time. A program as repeatedly outlined in yearbooks and articles seems to be emerging. The group felt that controversial subjects should be postponed till the child is older. The use of simple materials and community resources is improving and the area of outdoor and camping education is increasing.

Institutions were queried as to the problems which limit the growth of elementary school science. Lack of qualified instructors, faculty overload, lack of coordination and sympathy between education and science faculties were problems. Crowded curricula with a multiplicity of required courses; the conflict between academic and professionalized science and certification requirements were other problems. Students had inadequate high school background and were afraid of science. Buildings and facilities were lacking as were the state of the budget.

The problems of the graduate and inservice programs paralleled the above. In addition the matter of prerequisites and graduate quality of work haunted the institutions.

Elementary school teachers were considered as fearful of science, without background in science and poorly supported by school systems in trying to improve programs. Elementary curricula were crowded and science was incidental rather than basically important.

IMPLICATIONS OF THE STUDY

I would like to draw your attention to certain things indicated to me by the study. I believe that the faculties of schools of education and faculties of science departments need to work more closely together and to develop a sympathy for each other's problems. Within the framework of the usual 124 to 128 semester hours of undergraduate work much could be done to eliminate repi-

tition, competition and waste of time. Educators could do well to learn more science and college science teachers could do equally well in getting acquainted with the problems in the elementary schools.

Perhaps more people with elementary school experience might be added to college faculties. Programs might be instituted for communication between departments and between colleges and school systems. Science courses might be revised in terms of elementary school problems. Perhaps more colleges could offer a program in which students could minor or major in science for the elementary school. Certainly courses in elementary school science curriculum should be offered to help teachers learn how to construct courses of study. Perhaps graduate schools might go as far as to offer courses in administration and supervision of science to administrators. Local school systems might institute workshops in science using local personnel and college faculty guidance.

Above all more colleges need to consider in-service training as a most important service function. Many states now require more than four years of training for a permanent certificate.

College of education faculties in general must be persuaded that science is a basic curriculum area and as important as other tool subjects. Graduate schools have an opportunity in doing this in courses for building administrators, supervisors, and curriculum coordinators.

On the local level, administrators need guidance in including science in the program, in considering science instruction and its needs when building or rebuilding physical plants, and in persuading the public to support such programs financially. Administrators and school boards should be helped to realize the importance of having a qualified supervisory staff who can assist teachers in science as well as in spelling and arithmetic. This is increasingly important when we realize that in almost no other area are teachers more poorly prepared than in science. And in no other area are they more fearful of teaching.

Organizations like the N.A.R.S.T. might do well to emphasize to colleges the need for improving science training for elementary school teachers. Past research and studies have given us many excellent programs to follow in undergraduate science work for elementary school teachers.

I do not believe we dare give up just because other curricular areas are well entrenched and there seems to be no more room for science in the undergraduate curriculum. In view of the desperate need for more scientists and scientifically minded laymen, we must continue to present the case to college faculties, local schools, communities, industry, business and all levels of government.

SCIENCE, PHILOSOPHY, "COMMON SENSE"—AND THE AMERICAN HIGH SCHOOL

HAROLD H. PUNKE
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IN simple life there is little differentiation among such concepts as science, philosophy, and common sense—they tend to merge, and to be closely related to physical action. To a large extent, a similar lack of differentiation characterizes the non-vocational lives of many Americans today. However in a modern technological society, such as that of the United States, there is a continuous stream of new information of ever increasing volume which must be absorbed into the existing culture. When the number of people included in the culture group is large and their geographical spread

is extensive, there will be widely varying degrees in the extent to which the new is absorbed by different communities or individuals.

In a primitive society, or an isolated community within a complex civilization, integration of new elements into the culture pattern differs in two pertinent ways from integration into the broad main stream of a rapidly growing technical culture. (1) In the primitive culture changes do not come in rapid succession. Hence there is much time for one change to spread among the people and become adapted and integrated before another change appears. Anthropologists refer to several thousand years during which the group life of our primitive ancestors changed little—in comparison with the amount of change that now takes place in this country within a decade. Hence the task of keeping up-to-date was practically nil. (2) Moreover in primitive life the population groups were small, and each group rather closely knit together. Hence through primary contacts, new information could readily pass from one member of the group to another.

One net result of the situation described is that most of the knowledge possessed by a tribe as a whole became the common knowledge or common sense of all in the group—except for a few ceremonial and related practices in which "special knowledge" was reserved for a priest or similar person. There was no problem of subdivision or specialization in knowledge because the amount of existing knowledge was too great for one person to master. Whatever restrictions existed were those of privilege or vested interest.

By contrast, the rapid rate at which new knowledge has accumulated in the United States during the past century has greatly stimulated the rate at which new specializations have appeared. With a great mass of knowledge divided into specializations, only a small per cent of the total appear in the form of common knowledge which is possessed by everybody. Most of the great mass falls into some area of specialization —where it is the possession of a relatively small number of persons. Hence it is easy to differentiate the idea of common knowledge and common sense from the idea of technical knowledge and vocational sense.

Science is a term frequently used to refer to a large body of specialized knowledge as well as to a method by which new knowledge may be acquired. In the long run, scientific method which can be used to acquire various types of knowledge is more important in cultural development than the knowledge in a particular area which has already been acquired. Various efforts have been made to differentiate pure from applied science, on the basis of the extent to which research findings could be used in the immediate modification of man's life and environment. However it is becoming increasingly clear that this differentiation is artificial—that some of the most practical knowledge we have is general theory which draws together and interprets isolated facts, and formulates patterns according to which we can expect to add further knowledge. Hence a decrease in emphasis on the differences between pure and applied science seems appropriate.

Theory, as an effort to draw together and interpret or harmonize various facts and ideas, constitutes the core of philosophy. For some time it has been regarded as the task of philosophy to explain what happens in the universe—including the life of man. Explanations are always relationship phenomena—that is, facts and events have meaning and are explained in terms of and in relation to one another. So if it is considered the task of science to discover new facts in various areas of inquiry, it is the task of theory and philosophy to explain what those facts mean. Perhaps moral philosophy might be thought of as the area which formulates meanings or explanations in terms of their significance for man—rather than in regard to broader implications concerning the universe, in which man is a relatively small element.

When science and philosophy are conceived as indicated, each is essential to complement the other. A weakness of much philosophy is the absence of an objective basis of testing the theories advanced—beyond the facts which were taken into account in formulating the theory. Hence many authoritarian generalizations or dogmas have gone unexplored over substantial periods of history—in moral, political, religious, or other areas of philosophy. During the last few centuries science has increasingly offered a method of checking such generalizations—although some philosophers have not been especially alert in evaluating new scientific findings in terms of changes in earlier explanations which those findings make necessary, if all existing information is to be harmonized. On the other hand the findings of science can be sporadic and fragmentary, unless considerable effort at explanation and integration is made—both in regard to existing data, and in regard to the next things to look for. "Comprehensive" or "long-range" research projects are comprehensive or long-range because of the scope of existing data on which they are planned and the scope of possible further relationships and implications which they intend to explore. Whether scientists refer to their efforts at formulating explanations and theories as constituting philosophy, or whether philosophers refer to their efforts at finding evidence to support or refute their formulations as constituting science, is largely irrelevant. The two are interdependent. And in a society in which knowledge increases rapidly in volume and intricacy, the inseparability of science and philosophy should become increasingly clear.

Foregoing comments on science and philosophy do not imply that "common sense" gets lost in the shuffle—but those comments imply that common sense has a different status and a different role to play than in a simple culture. In a simple or primitive society common sense was with minor exceptions the sum total of all knowledge which the group possessed, whereas most of the knowledge that exist in a modern technical society is found in the different areas of specialization—as already noted. For a multiplicity of technical and specialized groups to hold together as an organized society, an important social task thus emerges—of moving substantial elements out of each of the specialized areas into the area of common learning or common sense. Hence technical information and treatises have to be simplified. What this means is that the knowledge embodied in such treatises, which is new to the common people, has to be connected with and discussed in relation to what they already know. Schools, journalism, radio, and other educational agencies help popularize new knowledge.

It should be obvious that there is a rapid and growing rate of increase in the body of knowledge which is common to average Americans—that is, in the background of common sense in terms of which they act—or judge events, people, and ideas. But this does not mean that once a particular item has entered the sphere of common sense it continues indefinitely in that sphere. Much of what constituted common sense and the basis of lay practice a century ago has since been discarded—and labeled "superstition." A short definition of a superstition is: an explanation which our ancestors gave for some event but which we have since come to regard as inadequate—or perhaps ridiculous. Folk tales about black cats, rabbit feet, and asafetida bags are illustrative—as are blood-letting as a universal remedy for illness; or the idea that if you had only a mild distemper some pink tea might help, but if you were really sick it took strong, bitter medicine to do any good. Personal hygiene and community sanitation are now "common sense" measures for preventing disease, but before Pasteur developed the germ theory of disease the common sense of the time included no such content. Our ancestors knew less

about cause and effect and had fewer instruments for accurate observation than we have. They accordingly explained more phenomena in terms of man-like deities than we do.

The area of American culture referred to as common sense is a changing area—expanding in total volume since the inflow is greater than the outflow, but undergoing continuous renovations or reconstruction. It becomes an increasing responsibility of public education, especially our secondary schools, to speed up the rate at which technical knowledge is transformed into the common sense of the people generally, and to develop in youth an understanding of the relative character of knowledge—that much of what we accept now will be discarded in the future as fogyisms and superstitions, the same as we now discard much of what was once commonly accepted. Youth need to realize that as the rate of scientific discovery speeds up, the rate of obsolescence in man's accepted ideas and practices also speeds up. Thus superstitions need to be identified and discarded at a more rapid rate.

Comment up to this point has related mainly to the United States—as among the technologically most advanced countries. However the next century will witness much scientific development in the Orient and Latin America. If a few hundred million additional people develop scientific orientation and research during the next century—that is, several times the number now so oriented and engaged, the world's body of accumulating knowledge will grow at a much faster rate than most persons are now able to imagine. So too will the rate of obsolescence in regard to what we now accept as known and established. High school teachers in both natural and social science should try to develop the imaginations of youth so youth can realize that their own ideas and conceptions of many things will become obsolete and "fossilized" more rapidly than was the case with their parents—and that these youth will therefore have a bigger job of keeping up-to-date intellectually.

To help a youth secure the needed information and develop the understanding indicated is to help him make a major stride in developing his own philosophy and capacity for evaluation. So far as average Americans are concerned, the public high school is the best instrument yet created for helping the individual develop a capacity to understand how scientific method may be used to test theory. While this nascent institution needs much improvement for the task indicated, it already has considerable possibility which could be more fully utilized.

SCIENCE IN THE NEWS

GERTRUDE B. HOFFSTEN
Program Coordinator KSLH, St. Louis, Missouri

LATE in the spring of 1955 KSLH was asked by the teachers of the science radio planning committee to think about a series of programs in science for pupils in the seventh and eighth grades which would help in interpreting the vast amount of science news being reported by the newspapers and periodicals. News of the International Geophysical Year with all its plans and implications seemed to them to be a springboard which could lead to greater interest in science at this age level.

A series was begun in the fall of 1956. Each program dealt with the news of scientific interest as reported in the newspapers. The broadcasters for this series were Dr. John D. Whitney, Dean of Instruction and professor of physics at Harris Teachers College and Mrs. Gertrude B. Hoffsten, coordinator for the science pro-

grams at the station and former teacher of biology at the college. Each week they would sift through news items, picking out those which would possibly need interpretation for boys and girls in the seventh and eighth grades. They would, on the air, call attention to the various items and either clarify or give background materials for each, leaving thought provoking questions with the listeners whenever possible. On many occasions, experts in the various fields of science would be asked to help with the programs. Some were accustomed to talking with youngsters, some were not. But Dr. Whitney and Mrs. Hoffsten, both familiar with children of this age and both experienced broadcasters, could channel the remarks and ask for elaboration and simplication when it was necessary. Listeners were encouraged to send in questions about topics on the programs or on others which they wanted clarified. Questions began to arrive after the first few broadcasts. On the next week's broadcast these questions would be answered or the broadcasters would give suggestions as to where to go or whom to ask for further information.

We made fast friends of the various scientists who helped with the programs and incidently added to our listening audience. In one office in the city, the personnel listened to the program on which one of their number was a guest. Later we received a letter saying that the whole office staff had listened regularly to the remainder of the series and enjoyed being kept on their toes with the science news.

Among the guest scientists who appeared on programs were a meteorologist, an astronomer, a geophysicist, an army engineer, a medical doctor, radio and television engineers, an ornithologist, an electronics expert, a naturalist, a farmer, a director of a nuclear laboratory, a research chemist, a test pilot, a physicist.

As is the custom with all KSLH program series, we asked for an evaluation from the teachers who had used the programs with their pupils. Enthusiastic requests for a continuation of the series came back from listeners. A few quotes from the returned sheets were:

"Don't take this series off the air. I could not possibly keep up with my eighth graders' questions and interests without it."

"This series has meant a great deal to the children and to me in interpreting the science news of the day."

"A great spurt in reading has resulted in my classes. Let's have another series."

"So much is going on, most of which is not even mentioned in our texts, we need this series. Keep the programs coming."

Science in the News carried on through the 1957–58 school year and is at present in its fifth series with requests for a sixth during the spring semester of 1959.

Since not even the broadcasters know until an hour or two before air time just what the program content will be, it keeps broadcasters as well as listeners alert to the latest news, and demands the use of discrimination in deciding the scientifically important items as opposed to the unimportant or merely sensational. This has resulted in the formation of an informal contest in some schoolrooms, we are told. The children clip science news items for their bulletin boards and have a lively discussion as to the importance of each and as to which will be used on the broadcasts. Others formulate questions they hope will be answered for them and are elated when their questions are the topics most stressed by the broadcasters.

In using this series the teachers tell us that no where else have they found materials which stimulate the children's great interest in what is new, and bring even an elementary understanding of vital science happenings. It has encouraged teachers as well as children to further investigation, guided their reading habits and been of great help to the science programs in their classrooms.

So *Science in the News* has become another sustaining series to be added to seven others which, during the nine years that KSLH has been on the air, have provided supplementary science materials for children and teachers from the kindergarten through grade eight.

A STUDY OF FORMULATING AND SUGGESTING TESTS FOR HYPOTHESES IN ELEMENTARY SCHOOL SCIENCE LEARNING EXPERIENCES *

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THE PROBLEM

The problem of this investigation was twofold: to ascertain the nature of children's development in certain aspects of their abilities to formulate and suggest tests for hypotheses in science learning experiences, and, secondly, to discover what relationship exists, if any, between the relative permissiveness of the classroom situation for problem-solving activity and the development of these abilities.

SIGNIFICANCE OF THE PROBLEM

The development of children's ability to solve problems is steadily becoming a more commonly accepted goal of public education. Curriculum workers point to the fact that the occurrence of problems is one of the few constants in the developmental process. At every level, youngsters are confronted with situations in which some factor initially prevents them from achieving something they consider desirable. To teach youngsters something about the varied approaches to the solution of such problems is becoming a major function of the schools.

While problem-solving skills may be stressed in all curricular fields, the close relationship of problem-solving behaviors to the process of scientific inquiry makes science learning experiences a particularly fertile ground for the study of some of these behaviors. Partly for this reason, problem-solving ability has become a primary concern of science educators. The ability to solve problems is listed as a major objective of science education in the *Forty-Sixth Yearbook*.[1] The National Association for Research in Science Teaching considers research in problem-solving ability to be of paramount importance, and committees of this group have tried to ascertain areas of needed investigation.[2]

There is some agreement among educational authorities that the dynamics of problem-solving may include the following behaviors:

1. Sensing a problem and deciding to find an answer to it.
2. Defining the problem.
3. Studying the situation for all factors bearing on the problem.
4. Making the best tentative hypothesis as to the solution of the problem.
5. Selecting the most likely hypothesis.
6. Testing the hypothesis.
7. Drawing a conclusion.
8. Making inferences based on this conclusion when facing new situations in which the same factors are operating.

There is no attempt here to imply that these behaviors are all the aspects of the problem-solving process or that these steps must be followed sequentially in the solution of a problem. One person, when faced with certain problems, may omit certain steps, telescope others, or start at a point that may be entirely different from the approach of another person. An individual may go back and forth among the behaviors. These steps are listed mainly for

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Based on the dissertation, "An Analysis of the Development of Elementary School Children in Certain Selected Aspects of Problem-Solving Ability," completed in partial fulfillment of the requirements for the degree of Doctor of Philosophy at the School of Education, New York University, 1956.

[1] "Science Education in American Schools," National Society for the Study of Education, *Forty-Sixth Yearbook*, Part I, p. 29.

[2] "Problems Related to the Teaching of Science that Need to Be Investigated," *Science Education*, April, 1950.

convenience in examining specific behaviors associated with problem-solving.

An underlying assumption in this study is that a crucial aspect of problem-solving behavior is the formulating and testing of tentative hypotheses. Yet there is little research indicating the bases for children's hypotheses, their accuracy, or the methods they suggest for testing hypotheses at different levels of development. For the development of problem-solving ability to become a major phase of classroom experience, there must be evidence outlining to curriculum workers how such development takes place—how it can be recognized and encouraged. This evidence is needed to describe children's development in *all* aspects of problem-solving ability. It is the purpose of the study reported here to outline *one* phase of such research: how children formulate and suggest tests for hypotheses in science learning experiences.

SELECTION OF CLASSROOMS FOR STUDY

For this investigation it was necessary first to select classrooms for study judged to be relatively permissive for the development of children's problem-solving ability. It was assumed that in such classrooms children would exhibit the behaviors under study more freely than in other types of classrooms. Children's development could then be described under "optimum" conditions.

It was also necessary for this investigation to select classrooms judged to be comparatively less permissive for children's problem-solving behavior. This selection was made in order to contrast children's development in the two types of situations and determine the possible effect of the permissiveness of the classroom setting—for problem-solving behavior—on the development of the abilities being studied.

Three different classrooms at grade one, four at grade three, and four at grade six were selected for study after being judged to be relatively permissive for children's problem-solving behavior. Six different classrooms were selected at grade one, five at grade three, and three at grade six after being judged to be less permissive—compared to the classrooms selected earlier—for the development of children's problem-solving ability. Each of the classrooms was in the same school system.

The classrooms were judged as to relative permissiveness for problem-solving by the investigator, the principal, and the helping teacher. The following criteria were used in selecting the classrooms judged to be relatively permissive.

1. Problems in science generally grew out of the interests and inquiries of children.
2. Problems were defined by teacher-pupil planning.
3. Hypotheses were formulated by the children.
4. Problems were solved by a combination of individual and group effort.
5. Children applied their solutions to the original problem situation.
6. Children evaluated, with the teacher's help, their own problem-solving efforts.

Only as there was complete agreement among the three judges was a particular classroom selected as a source of data for the study. The same judges also selected the classrooms that were relatively less permissive for problem-solving.

COLLECTION OF DATA

All data were obtained during the investigator's discussions with children in the selected classrooms. In every case, the investigator was working with the youngsters as part of his function as elementary science consultant in the school system used for the study. Thus, the youngsters knew the investigator. They were accustomed to working with him.

Data were obtained when the children in the selected classroom were ready to formulate and suggest tests for hypotheses. The discussions were recorded on tape in their entirety. At each session, the investigator attempted to lead the discussion in a manner that elicited data indicating the dynamics of children's hypothesizing. Twenty recordings were collected at each of three grade levels studied: one, three, and six.

Half the recordings at each grade level were taken in the classrooms judged to be relatively permissive for problem-solving; half were taken in the less permissive classrooms.

CATEGORIES FOR ANALYSIS OF THE DATA

In the broad category "Formulating Hypotheses," the children's responses were analyzed for three subsidiary aspects in this investigation:

1. Bases for the Hypothesis
2. Assumption Underlying the Hypothesis
3. Accuracy of the Hypothesis

Initially, each of these sub-categories was further refined as indicated:

1. Basis for the Hypothesis
   Authority
   Observation
   Experiment
   "Original" Guess
   No Verbal Explanation
2. Assumptions Underlying the Hypothesis
   Failure to Recognize Assumptions
   Recognition of Assumptions But No Resultant Action
   Assumptions Recognized and Acted Upon
3. Accuracy of the Hypothesis
   Correct Hypothesis
   Incorrect Hypothesis

In the broad category "Suggesting Tests for Hypothesis," the children's responses were analyzed under the following three subsidiary aspects:

1. Methods Suggested for Testing Hypotheses
2. Experimentation Suggested for Testing Hypotheses
3. Measurement Suggested for Testing Hypotheses

Each of these sub-categories was further refined as follows:

1. Methods Suggested for Testing Hypotheses
   Authority
   Observation
   Experimentation
2. Experimentation Suggested for Testing Hypotheses
   Control Suggested
   No Control Suggested
3. Measurement Suggested for Testing Hypotheses
   No Measurement Suggested
   Descriptive Measurement Suggested
   Quantitative Measurement Suggested

These categories were selected by the investigator from extensive lists of the elements of children's problem-solving behavior appearing in the literature. The selected categories were judged by the investigator—on the basis of a pilot study—to be those most readily analyzed by the technique employed here.

ANALYSIS OF THE RECORDINGS

The investigator listened to each of the sixty recordings and noted the number of children's responses in each of the categories above. A total of 1264 responses were noted by this method. In Table I, the number of responses in the area of Formulating Hypotheses is reported. In Table II, the number of responses in the area of Suggesting Tests for Hypotheses is reported. Data in these tables are grouped by grade level without regard to the type of classroom in which they were recorded.

To check the validity of the investigator's analysis of the recordings, a jury of three educators analyzed a sample of the sixty recordings. The sample consisted of the first three recordings and then every tenth. The analyses of the jurors were no more than 4 per cent at variance with the analysis of the investigator in any one category.

To check the reliability of the methods employed for analyzing the data, the investigator listened to a 20 per cent sample of the sixty recordings three months after the initial analysis. There was better than 92 per cent agreement in each sub-category between the two separate analyses.

THE BASES FOR CHILDREN'S HYPOTHESES

Data are presented in Table III reporting the calculation of significance by chi-square for the categories reporting the bases of children's hypotheses at the different grade levels. Data are drawn from Table I. The numbers in parentheses in the table indicate the frequency to be expected on the basis of a chance distribution.

TABLE I

Frequency Distribution of Children's Responses While Formulating Hypotheses into Specific Sub-Categories in Grades One, Three, and Six

Category of Response	Grade 1	Grade 3	Grade 6
Basis for the Hypothesis			
Authority	26	32	54
Observation	52	58	19
Experimentation	7	8	9
"Original" guess	27	50	29
No verbal explanation	176	269	159
Total	288	417	270
Accuracy of the Hypothesis			
Correct	210	329	224
Tenable	12	5	0
Incorrect	66	83	46
Total	288	417	270

The frequency tabulation in the category "Suggesting Tests for Hypotheses" is reported in Table II.

TABLE II

Frequency Distribution of Children's Responses While Testing Hypotheses into Specific Sub-Categories in Grades One, Three, and Six

Category of Response	Grade 1	Grade 3	Grade 6
Methods suggested			
Authority	33	27	18
Observation	20	15	1
Experimentation	54	48	41
Total	107	90	60
Experimentation suggested			
Control suggested	6	3	10
No control suggested	48	45	31
Total	54	48	41
Measurement suggested			
Descriptive measurement	2	5	2
Quantitative measurement	0	2	2
Total	2	7	4

The major finding regarding the bases for children's hypotheses is that at the higher grade levels in the elementary school, children tended to express the use of authority as the basis for their hypotheses significantly more than children in the lower grades. Also children in the lower grades tended to express the use of observation as the basis for their hypotheses significantly more than children in the upper grades.

Accuracy of Hypotheses

Data are presented in Table IV indicating the frequency of accuracy of children's

TABLE III

CHI-SQUARE DETERMINATION OF THE SIGNIFICANCE BETWEEN GRADE LEVELS OF THE VARYING FREQUENCIES WITH WHICH CHILDREN EXPRESSED DIFFERING BASES FOR THEIR HYPOTHESES AT THE THREE GRADE LEVELS

Categories of Response	Grade 1	Grade 3	Grade 6	Totals
Authority	26 (33.8)	32 (44.7)	54 (33.6)	112
Observation	52 (38.9)	58 (51.4)	19 (38.6)	129
Experimentation	7 (7.2)	8 (9.6)	9 (7.2)	24
Original guess	27 (32.0)	50 (42.3)	29 (31.7)	106
Totals	112	148	111	371

Chi-Square = 36.15
df = 6
P is less than .01

hypotheses and a chi-square determination of the relationship between this factor and grade level.

METHODS SUGGESTED TO TEST HYPOTHESES

Data in Table V report the relationship between the frequency of different methods

TABLE IV

CHI-SQUARE DETERMINATION OF THE SIGNIFICANCE OF THE RELATIONSHIP BETWEEN GRADE LEVEL AND THE FREQUENCY OF CORRECT AND INCORRECT HYPOTHESES

	Grade 1	Grade 3	Grade 6	Totals
Correct	210 (216.1)	269 (275.6)	224 (211.4)	703
Incorrect	66 (59.9)	83 (76.4)	46 (58.6)	195
Totals	276	352	270	898

Chi-square = 4.94
df = 2
P lies between .10 and .05, closer to .10

The data in this investigation do not show that there is a significant relationship between children's ability to formulate correct hypotheses and grade level. Note, however, that at each grade level studied, children hypothesized frequently.

suggested for testing hypotheses and grade level and a chi-square determination of significance.

The difference in frequency response in methods suggested to test hypotheses at different grade levels was not found to be

TABLE V

CHI-SQUARE DETERMINATION OF THE SIGNIFICANCE OF THE DIFFERENCE IN GRADE LEVEL IN THE ELEMENTARY SCHOOL AND THE METHODS CHILDREN SELECT TO TEST HYPOTHESES

Methods Suggested	Grade 1	Grade 3	Grade 6	Total
Authority	33 (32.5)	27 (27.5)	18 (18.2)	78
Observation or experimentation	74 (74.5)	63 (62.7)	42 (41.8)	179
Total	107	90	60	257

Chi-Square = .0189
df = 2
P is approximately .99

significant in this investigation. Children in the upper elementary grades tended to suggest both authority and empirical techniques for testing hypotheses at frequencies not significantly different from children at lower grade levels.

Note, however, that the frequency with which children suggested tests for hypotheses, of either type, decreased sharply from the lower grades to the upper grades.

HYPOTHESIZING IN CONTRASTING CLASSROOM SETTINGS

The frequency of responses are grouped In Table VI on the basis of the relative permissiveness of the classroom setting for the development of children's problem-solving ability. A chi-square determination of the relationship between the classroom setting and the basis for children's hypotheses is reported.

cantly more than children in a less permissive classroom setting.

Data are reported in Table VII indicating the relationship between the classroom setting and accuracy of hypotheses by a determination of the coefficient of tetrachoric correlation, r_t.

The approximate formula for r_t used in this investigation is:

$$\frac{ad-bc}{N^2 zz'} = r_t + \frac{XX'r_t^2}{2}, \text{ in which}$$

x and x′ = sigma distances from the means to points separating the proportion in the upper category from the proportion in the lower category

z and z′ = the heights of the ordinates at the points of division

a, b, c, and d = entries in the four cells

N = number of cases

r_t = the tetrachoric coefficient of correlation

TABLE VI

CHI-SQUARE DETERMINATION OF THE SIGNIFICANCE OF THE DIFFERENCE BETWEEN THE FREQUENCIES OF CHILDREN'S RESPONSES REGARDING THE BASES FOR THEIR HYPOTHESES IN PERMISSIVE AND LESS PERMISSIVE SITUATIONS

Data are Grouped from Grades One, Three, and Six

Category of Response	Permissive Setting	Less Permissive	Total
Authority	49 (65.8)	63 (46.2)	112
Observation	76 (75.8)	53 (53.2)	129
Experimentation	21 (14.1)	3 (9.9)	24
"Original" guess	72 (62.3)	34 (43.7)	106
Totals	218	153	371

Chi-Square = 22.25
df = 3
P is less than .01

A highly significant relationship between a classroom setting judged to be permissive for problem-solving and the bases for children's hypotheses as categorized in this study is indicated here. Looking at the individual cells in Table VI, it seems that children in a relatively permissive classroom atmosphere expressed authority as the basis for their hypotheses significantly lower than children in a less permissive atmosphere. These children also tended to make "original" guesses when hypothesizing signifi-

In this case $r_t = .04$ indicating an almost negligible correlation between the accuracy of the hypothesis and the relative permissiveness of the classroom setting as determined in this study.

Data are presented in Table VIII indicating the frequency of different methods suggested for testing hypotheses in the contrasting classroom settings. The calculation of r_t is also reported.

While a positive coefficient of correlation of .38 between a relatively less permissive

TABLE VII

COMPARISON OF THE FREQUENCY OF CORRECT AND INCORRECT HYPOTHESES IN PERMISSIVE AND LESS PERMISSIVE CLASSROOM SITUATION

Category of Response	Permissive	Less Permissive	Total
Correct	406 (b)	357 (a)	763 ($p = .80$)
Incorrect	108 (d)	77 (d)	185 ($p = .20$)
Total	514 (q′)	434 (p′)	948 (N)

($q' = .54$) ($p' = .46$)
$r_t = .04$

TABLE VIII

CALCULATION OF r_t BETWEEN AUTHORITARIAN AS CONTRASTED TO EMPIRICAL METHODS OF TESTING HYPOTHESES AND PERMISSIVE AS CONTRASTED TO LESS PERMISSIVE SITUATIONS

Category	Permissive	Less Permissive	Total
Authority	28 (b)	50 (a)	78 ($p = .30$)
Observation and experimentation	108 (d)	70 (c)	178 ($q = .70$)
Totals	136	120	256

($p' = .47$) ($q' = .53$)
$r_t = .38$

classroom setting and children using authority rather than empirical methods of testing hypotheses is not high, the standard error of this coefficient is approximately .075 indicating reliability at the .01 level.

I.Q. AND METHODS OF TESTING HYPOTHESES

Since data were available on the mental ages of all children in grades three and six, it was possible to determine the relationship between I.Q. and methods suggested for testing hypotheses. A determination of biserial r for this relationship is reported in Table IX.

The r_{bis} of $-.024$ found in this investigation indicates almost no correlation between I.Q. and either authoritarian or empirical methods of testing hypotheses.

SUMMARY OF FINDINGS

Within the limitations of the experimental design, the following statements seem to the investigator to summarize the major findings of this study:

1. Elementary school children hypothesized readily in science learning experiences at the grade levels studied.

2. Children seemed to use a variety of sources when formulating hypotheses: au-

TABLE IX

DETERMINATION OF r_{bis} BETWEEN INTELLIGENCE SCORES AND AUTHORITARIAN AS CONTRASTED WITH EMPIRICAL METHODS OF TESTING HYPOTHESES

I.Q.	Frequency of Use of Authority	Frequency of Use of Observation or Experimentation	f
140–144	1	0	1
135–139	1	3	4
130–134	3	1	4
125–129	1	10	11
120–124	3	7	10
115–119	4	9	13
110–114	5	12	17
105–109	8	15	23
100–104	5	9	14
95–99	3	9	12
90–94	4	3	7
85–89	0	1	1
	38	79	117

$$r_{bis} = \frac{M_p - M_q}{\sigma} \cdot \frac{PQ}{Z}, \text{ where:}$$

$M = 111.49$ (mean of all I.Q.'s, $N = 117$)
$\sigma = 12.00$ (of all scores, $N = 117$)
$M_p = 111.21$ (mean of I.Q.'s of those using authority)
$M_q = 111.69$ (mean of I.Q's of those using empirical method)
$p = .32$ (proportion of children using authority)
$q = .68$ (proportion of children using empiricism)
$z = .358$ (height of ordinate separating p from q in normal distribution)
$r_{bis} = -.024$

thority, experimentation, observation, and "original" guesses.

3. Children at all grade levels in the elementary school seemed interested in each of the major broad science content areas, i.e., astronomy, living things, structure of the earth, light, sound, etc. The range and depth of the problems, as well as the specific sub-topics, seemed to change in children's interests from year to year rather than the broad science content area.

4. The children studied in this investigation seldom recognized assumptions that they made while hypothesizing. The educators who served as jurors for this study also had difficulty recognizing children's behavior that indicated recognition of assumptions.

5. With the exception of the recognition of assumptions, it was found that the jurors and the investigator were able to recognize all the other aspects of problem-solving behavior analyzed in this study.

6. Children studied in this investigation were frequently unable to state the basis for their hypotheses.

7. Children in the upper elementary grades tended to employ authority when formulating hypotheses in science learning experiences significantly more than children in the lower elementary grades. Younger children, on the other hand, tended to use observation as the basis for formulating hypotheses significantly more than older children.

8. At any one of the grade levels studied in this investigation children hypothesize with about the same frequency of accuracy as children at any other grade level studied.

9. The children in the upper elementary grades studied in this investigation tended to suggest tests for hypotheses, of any sort, less frequently than children in the lower elementary grades.

10. Children, at all grade levels studied, tended to use empirical methods of testing hypotheses more than they used authority. Further, the relative frequency with which they used empirical methods compared to the relative frequency with which they used authority did not appear to change from grade to grade.

11. Children in the classrooms judged to be relatively permissive for children's problem-solving behavior tended to express authority as the bases for their hypotheses at frequencies significantly lower than the children hypothesizing in classrooms judged to be less permissive. Also, children in the relatively permissive classroom settings tended to employ "original" guesses in formulating hypotheses significantly more than children in less permissive classroom settings.

12. Children hypothesizing in classrooms judged to be permissive for problem-solving activity hypothesized neither more accurately nor less accurately than children hypothesizing in classrooms judged to be less permissive.

13. Children in relatively permissive classroom situations for problem-solving employed empirical methods of testing hypotheses significantly more than children in less permissive situations.

14. There seems to be no evidence, based on the data in this study, that children with higher intelligence scores select either authority or empirical methods of testing hypotheses at frequencies significantly different from children with lower intelligence scores.

SUMMARY OF IMPLICATIONS

Within the limitations of the experimental design, the following statements seem to the investigator to summarize the major implications of this study.

1. Classroom teachers might recognize the fact that children as young as six years old are capable of understanding cause and effect relationships. Teachers of children in all the elementary school grades might well plan for educational experiences that stress the further development of this ability if it is considered a major goal of elementary education.

2. Teachers might recognize the fact that

children in the elementary school are capable of employing a variety of sources when hypothesizing, such as authority, observation, and "original" guesses. They might encourage children to evaluate these sources, use the best ones, and thus become more effective at problem-solving.

3. If recognition of assumptions is considered a major goal of elementary education, curricula should be revised to make possible the more effective learning of this ability than was noted in this study.

4. The problem-solving behaviors studied in this investigation constitute a realistic expectation, in terms of child development for classroom practice.

5. Children should be encouraged to recognize the fact that they might use a variety of bases for formulating hypotheses. They might be taught to evaluate these bases as they solve specific problems.

6. Special opportunities might be given for children in the upper elementary grades to suggest tests for hypotheses if suggesting tests for hypotheses is considered a major goal of elementary education.

7. Teachers might help children to recognize the bases for their hypotheses to a greater extent than was common in classrooms studied in this investigation.

8. Older children in the elementary school, particularly, should be encouraged to formulate hypotheses based on "original" guesses and observation as well as authority.

9. If originality is considered desirable when children hypothesize, it should be noted that children exercise this behavior most effectively in classrooms where they, in part, select the problems they work on.

10. If empirical techniques for testing hypotheses, in contrast to authority, are considered desirable for children, it should be noted that elementary school children use these techniques significantly more when they solve problems in classroom settings in which they participate in selecting the problems they work on.

PLANNING FOR LABORATORY RENOVATION

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So many new school buildings have been constructed recently, that some good empirical information is being accumulated on laboratory planning. Experienced instructors who have struggled for years to teach in limited laboratories, under handicaps of inadequacies in preparation and storage space, and outdated furniture, welcome the chances to express their needs in new building plans. True, other departments put in their bids too, and hopes must be trimmed in conformance with the realities of architecture, space, and budget.

A fortunate few have even managed to be included in the planning of several new schools, and have thereby acquired substantial experience. Published materials to help in laboratory planning are rather scarce.* ‡ Nevertheless, schools constructed since World War II are generally far more suited for the work of education than were those of earlier eras. The greater volume of recent school construction has enabled builders, architects, and educators to ac-

* A useful guide is: *School Facilities for Science Instruction*, John I. Richardson, Editor, National Science Teachers Association. Washington, D. C., 1954.

‡ Provisions of the recently passed National Education Defense Act makes money available to certain schools for purchase of laboratory materials.

cumulate a body of "know how" that is even growing specific for school building. There is a group of architects recognized as specialists in the school field.

In the seemingly never-ending race to build new facilities, there is noticeable an important casualty. Maintenance and renovation have, in many places, become sketchy or spasmodic. There are, of course, still a number of schools in stable communities that have been operating for many years. Renovation is unspectacular, and enthusiasm for the task is difficult to generate in comparison with showy new projects. Thus it is that maintenance and replacement budgets are diverted to new construction. Neglect of proper upkeep carries at least several long-range consequences, aside from the immediate material effects. Morale factors, for example, are very important. The teacher working with antiquated deteriorating facilities may find the obstacles too formidable, and consciously or otherwise slip into teaching that is below his best. Equipment in good repair of course encourages further care. What is perhaps most important to students, teachers, parents, and community, is the realization that the administration is lending support to good teaching everywhere.

Even in more tranquil days, systematic provision for maintenance based upon inventorying, depreciation appraisal, extent of usage data, and the like, were the exception rather than the rule. More characteristically, attention is given to the need that appears to be the most pressing, whether it be for science or for any one of a score of other demands. Administrative decisions on expenditures normally must carry detailed justification. If, then, a science need requires administrative attention, the department head or other responsible person must expect to shoulder the responsibility detailing it and bringing it to notice in a way that will result in favorable action.

It is hard to find printed material pertaining to procedures for inventorying, appraising usage, and estimating depreciation of school equipment. Depreciation schedules for school laboratory furniture share in this scarcity. An old federal bulletin permits for tax purposes, a ten per cent annual depreciation on science furniture in commercial laboratories. This rate is far higher than that allowable in school laboratories. The working out of a realistic depreciation scale for educational facilities is complicated by many variables. Some of the most obvious that might be cited are volume of daily and annual usage—including day, evening, and summer enrollment, the character and advancement of the students, extent of individual laboratory work, and the efficiency of the teaching and custodial staff. Aside from depreciation alone, changing instructional needs may justify changes in facilities.

SOME USEFUL PROCEDURES

The importance of maintaining departmental records for many purposes cannot be over emphasized. They are directly useful in contemplating improvements. It should be possible to display in convenient form statistics on student enrollments and laboratory usage over any time interval.

Department meetings are important in order to coordinate thinking and action. Agreement is needed on whether change is desired, and on what the alterations should be. If needed changes are extensive, what priority should be established? At this stage it is generally advisable to send a written memorandum through the principal to the appropriate school official. Conversations and telephone calls lack impact, and do not remain in the memories of persons bombarded with other details. The most effective memorandum is concise and graphic. Included can be statistics on extent of departmental services to students past and present, the specific handicaps now interfering with fulfilling the curriculum, and the benefits to be anticipated from new facilities. Photographs add emphasis. Another useful inclusion is an invitation to the administrative official to make a visit of

inspection, and an offer to submit detailed plans.

The sequel to a favorable reception of the memorandum is considerable individual and group work by the department. Extensive background information needs to be assembled. This can be aided by examining catalogues, inspecting convention displays, and visiting other schools for study of facilities in use. Often representatives of laboratory supply companies can be helpful. It must be made very clear in advance, however, that no obligation is thereby being made to any company. Care needs to be taken not to impose upon the commercial personnel. Subject to the requirements of cost, space available and intended use, decisions can be made by the science teachers on the equipment desired. Floor plans and other diagrams can be prepared, often with the help of the shop department.* Detailed descriptions with appropriate standard catalogue numbers are important. Some mechanical background is a source of much security to the department head in carrying through the renovation process. Indeed, mechanical experience is helpful in laboratory work and is valuable in the preparation of all science teachers.

Since budget decisions are made once each year in many school systems, it is important that the submission of plans and reports be properly timed, so as to receive proper consideration. Frequently the department head is asked to explain and justify the requests before policy-making individuals or groups. The written report and drawings help to lend authority and direction to the verbal presentation. The favorable testimony of graduates who have gone on into scientific careers, and the support of parent groups may be helpful. This outside help should be used in a very circumspect way, lest there develop an embarrassing atmosphere of lobbying or special interest pressures.

REDEDICATION

If and when, all the steps outlined have been taken, and the renovations have been completed, additional procedures can be followed for realizing maximum effectiveness from the renewed facilities. Too often the workmen pack their tools and depart, while teaching resumes in a "business-as-usual" fashion, as though there never had been any interruption or change. Renovated surroundings can well be the springboard to new departmental planning of instruction. Ideas that were impracticable before may now be more feasible. Agreement is needed on how the new facilities are to be utilized, and responsibilities for their care need to be apportioned among the members of the department.

Publicity at this point has many worthwhile outcomes. The story of what has been accomplished should be brought before parent, alumni, and community groups. Local newspapers serve as a good medium. Informal dedication activities may include an "open house" for the public, graduates, and industrial representatives, and an assembly program featuring science. Having "company" puts the school on its mettle. The children of the community and their parents have their interest and confidence strengthened in the school. The demonstration that a long-established school is keeping "up-to-date" helps to offset much illogical envy for new schools. Alumni, especially those engaged in scientific occupations, and representatives from science and industry can be invited to further the work of the school. Science tours for children of the neighborhood schools can be arranged with pride.

Suitable "rededication" and publicity for

* In partial answer to limited wall and storage space in renovating a 40 year old biology laboratory, the science department at Frankford High School in Philadelphia recommended the construction of a shelf with dimensions of 16 x 54 inches, mounted six feet above the floor with rows of hooks on the lower surface spaced 3½ inches apart. This can be used for hanging as many as 48 charts by a screw eye in the end of the roller. This arrangement was suggested by Mr. William H. Gregory, Special Assistant in Science for the Philadelphia Public Schools, who disclaims any originality for the idea.

restoration and improvement of older buildings are also gestures of appreciation and encouragement to educational officials and boards of education. They, too, are human, and a knowledge that "making over operations" are not thankless and ignored routines will help insure that other such projects will not be slighted.

FROM THE ACORN GREW AN OAK

Irene G. Oppenheim
*365 C Schley Street,
Newark, New Jersey*

I wish I knew
Where it all began
Was it in the era
Somewhere before man?
That oak from acorn
First began.

The oak from a fertile acorn grew.
The acorn came from the union of two.
The pollen from the catkin's staminate
Met the ovary's cell in pistillate.
From the three cells two aborted away,
Leaving only one forlorn
To grow into a fertile acorn.

This acorn fell upon the grass,
And then some squirrel did pass.
He ate the nut,
And swallowed the seed.
The seed remained intact
Throughout the squirrel's intestinal tract.
The squirrel did eliminate
An oak to propagate.

This oak grew large, stately, and tall,
Or perhaps bushy and small.
Great trees and little bushes
From acorns grow.
Which only goes to show
What different trees from acorns grow.

But 'though an oak
Be large or small,
Acorns do fall
When frost tinges the air,
And the round-lobed
Rich, green leaves
Turn to purplish-brown
And blow through the air.

All oaks whether tall or small
Happen to fall
In north temperate zones
And tropics all.
Artic cold they do abhor,
And are seen there nevermore.

The oak that we know best
Is bigger than some of the rest.
Quercus alba, white oak by name,
Its strength is its fame.
The tall thick trunk
Supports the whitish boughs
From which abundant green leaves grow.
These leaves provide a haven of shade
From summer's sun, a shady glade.

"OUT OF THE MOUTHS OF BABES . . ." *

IRVING W. KNOBLOCH
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ONE hesitates to speak of the crisis facing America in regard to Russia's superiority, at least for the time being, in various destructive devices because the subject has been covered from a great variety of angles. Some of the causes, direct and indirect, which have been mentioned are inter-service rivalry carried to the point of inefficiency (apparently admitted), a paucity of theoretical scientists (refugee foreign scientists made possible our development of the atomic and hydrogen bombs), faulty thinking by some of our leaders ("it is inconceivable that Russia will be able to overtake us in science or technology"), mal-distribution of scientists and technologists (too many of our *good* men in industry working on *yearly* models of automobiles, refrigerators, TV sets, toasters and washing machines) and, lastly, a faulty educational system (the subject of this article).

Some of the criticisms leveled at our educational system have been made by educators like Paul Woodring (A Fourth of the Nation, McGraw-Hill) who *are* able to see the forest rather than the trees. Woodring believes that the progressive movement became too leftist and while purporting to adjust the students for life situations, was actually doing the opposite. Lack of report cards, grading on effort alone, neglect of superior students and undeserved passing of students destroyed the healthy competition so necessary as a preparation for life. The inclusion of driver training, social dancing, and other such courses, most properly taught in the home, and the over-emphasis on extra-curricular activities such as sports of all kinds, so diluted the curriculum that not enough time was left for the teaching of basic skills, without which a student is *not* educated. Although basic skills are paramount in our society and the development of critical thinking ability and respect for knowledge are of equal importance, yet few would say that these are the only goals of education. The point is, however that these objectives *must* be attained above all else.

The purpose of this article is not however to review all that has been said on the subject, pro and con. Dozens of articles on our educational system lie before me as I write. Rather, I would like to give some

* Contribution No. 106 from the Department of Natural Science, Michigan State University.

examples of student reaction to their high school training. In response to a request, about fifty students turned in papers evaluating the good and bad (as they thought) points of their alma maters.

Since the most important individual in any school system is the teachers, we will mention this first. Half of those replying to this point stated that they had very good teachers; helpful, patient and competent. About as many were somewhat disappointed in their teachers because they were too dull or taught at too advanced a level. A few mentioned that their science teachers were off-duty coaches and not competent or interested in science. This situation is well known and certainly must be corrected if we are to interest high school students in science.

The caliber of counseling was high in some (one half) and poor or absent in other schools. Library and shop facilities were rated good or bad in the same proportions.

About half of the students were satisfied with their English courses. The others had various comments to make such as—no themes or essays required, no opportunity to speak in class and the stressing of literature rather than grammer. A little less than half were satisfied with their science course(s) while the majority stressed poor motivation, little or no equipment for laboratory work and a narrow choice of science subjects. An overall impression which I receive is that improvements can be made in every high school, in one or more areas.

There were no schools wholly bad. In fact, many students speak quite highly of the over-all conditions in their schools and are willing to assume most of the blame for their subsequent failure or difficulty in college.

A surprising number bemoaned the fact that the high school had become "the home of the body" and not "the home of the mind." It was felt that too many extra-curricular activities were permitted or encouraged. One counselor, it was recorded, would not permit the student to take all "hard subjects because such a policy would interfere with their social activities. One student wrote to this point as follows: "We do not go to school to become socially acceptable. This should be taught in the home. We go to school to learn." Many noted that sports were emphasized more than the development of thinking ability. One very bright person observed that more money was spent on athletic facilities than on laboratory equipment.

The two topics mentioned most often, and, this *is* surprising, were (1) not enough homework was assigned and not enough studying encouraged, and (2) students were permitted to take too many easy subjects; courses which did not really challenge the mind.

Various miscellaneous complaints were made, each by one or two individuals, such as no foreign language were offered or little choice in this field, poor discipline in the school, poor teacher morale and no objective tests were given.

College and secondary education differ in at least one important respect. The worth of a college education can only be assayed years after graduation. The parents of high school students, however, are more quickly able to judge the mental progress of their offspring. For this reason, it seems apparent that parents can and should act in making known their reactions to school programs. Parent-Teachers Associations, sad to relate, are not noted for their courage in discussing controversial issues affecting the minds of the students. A school board member informed me that the main functions permitted to him were the passing of the budget or the raising of money. The public has a great stake in education and should be consulted, leaving the details to the experts. The latter are all those in education and other departments of a university who can intelligently lay out a curriculum plan to (1) produce a sufficient number of superior thinkers to direct the destinies of our country (2) stimulate critical thinking in all, and (3)

make sure that all students have the ability to use the basic or fundamental skills of reading, speaking, writing, listening and figuring. The above three items would seem to have top priority and can be obtained in such courses as English, history, science, social studies, languages, and others.

If one adopts an objective attitude toward our primary and secondary schools, one must say that the general pattern is good, being excellent in some schools and only fair in others. Unless we adopt the thesis that we possess the ultimate truth in educational matters, we can improve almost every school in some way or other to meet the *new* challenges confronting us in the second half of the twentieth century.

SCIENCE AT YOUR FINGERTIPS—EFFECTS OF AIR IN MOTION *

ALFRED D. BECK

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At the Sea View Hospital on Staten Island a small group of children waited near a television receiver. These boys and girls of various ages, races, and social backgrounds are all sufferers from tuberculosis and so they cannot go to school with healthy children. But they are as anxious as other children to see demonstrations of scientific facts and principles that explain the mysteries of life and living.

In other parts of the city, in homes, and hospitals, other children watched and waited, their receivers tuned to Channel 11. It was Monday morning and time for another of the weekly lessons in the series "Science at Your Fingertips" presented by teachers and supervisors of the Board of Education for the sick and physically handicapped children of New York City. In Mount Vernon, New Jersey, and several localities in Connecticut, other children were coming to attention.

Up in Studio 1 on the tenth floor of the News Building on East 42nd Street others were attending to their duties. Gathered there was a group of adults, each with a special job to do. The announcer, floor manager, cameraman, operator of the boom microphone, prop men, and the teacher, were standing by—ready. Here too were a half-dozen teen-agers, students from the High School of Performing Arts and and Stuyvesant High School. And nearby in the control room were the producer, the director, and their assistants. It was 10:44 A.M.

Since 9 o'clock the studio and the control room had been scenes of concentrated activity. Some one described it as "organized chaos." In the studio a blackboard had been set up at an angle to a ten foot table. Farther to the right a "serving table" had been placed. In front of these there were two desks for pupils and at one side a small TV receiver known as a monitor. Beyond were the three dollies—one for the boom microphone, and one for each of the two cameras. Overhead were the banks of blazing lights so essential in a television studio. On the tables was the apparatus needed for the lesson and in another room a motion picture projector was threaded, focused, and ready for use.

After these preparations had been made there had been two rehearsals—a "dry run" without cameras and "run through"

* One of a series of lessons in general science given by Alfred D. Beck, Science Supervisor, New York Public Schools, J. H. S. Division on "The Living Blackboard," WPIX, Channel 11.

with the cameras, taken, as they say in TV studios, "from the top" which means from the beginning of the script. Only there was no script, just an outline of the action which the teacher had prepared days ago and modified during the rehearsals. Otherwise the lesson was to be given just like a lesson in school—ad lib.

Then the signal came. The announcer began his introduction. We were on the air. The following is an account of the way in which the lesson was developed step by step:

1. A brief introduction to help the students recall what had been taught in the previous lesson: that air is a real substance; that it occupies space; that it has weight; and that it exerts pressure. The Magdeburg Hemisphere demonstrated in the previous lesson were shown (but not redemonstrated) to aid the pupil to recall these facts.

2. A clarification of the title of the lesson was then given to explain what is meant by "air in motion." Air is always in motion, but a stream or mass of air in motion is something else again—a wind, causing interesting and sometimes unexpected effects. To illustrate the camera was focused on the cover of the *Saturday Evening Post* that showed the same effects of air set in motion by an express train passing through a railroad station. You may remember how the wind thus created played havoc with a group of commuters who were waiting for a train.

3. Attention was then called to four simple "teasers." By a teaser is meant a thought provoking experience which poses a problem the viewers will be anxious to solve. These were demonstrated by the teacher and pupils working together. First, two milk bottles were drawn together when a stream of air was blown through the space between them. Next, the impossibility of blowing a table tennis ball out of a funnel by blowing through the stem was shown. Third, it was demonstrated that it is not possible to blow a flat card away from a spool by blowing through the hole in the spool. The fourth "teaser" showed that it is possible to float a table tennis ball and two round toy balloons simultaneously in the stream of air coming out of a vacuum cleaner tube.

4. Now that a problem situation had been created, a search for the solution was in order. The name of Daniel Bernoulli which had been written on the blackboard beforehand was now shown for the first time. Below his name were the years of his life span, 1700–1782. Reference was made to his explanation of such effects, the Bernoulli Principle. A *Venturi* tube was drawn on the board. Below it a *manometer* was sketched. Since these were new terms, a model of each item was shown. The model of the manometer was operated first. This showed the viewers that increased pressure (in this case the pressure of the fingers on a rubber diaphragm) causes the colored fluid in one arm of the manometer to go down while the fluid in the other goes up.

5. Returning to the blackboard, the teacher extended the drawing of the arms of the manometer and joined them to the Venturi tube; one arm to the wide part of the tube, one arm to the narrowed, central portion of the Venturi tube.

6. Then, the demonstration table having been rearranged by a pupil assistant, a home-made piece of glass apparatus of this type was demonstrated. The pupil blew through the tube and at the same time the teacher pointed out the motion of the fluid in a small manometer attached to it in the manner previously described.

7. Again at the blackboard the effects were recorded by altering the Venturi manometer diagram. Now diagrams showing the explanation of the "teasers" were drawn. Transition was made from the explanation of the balls suspended in the air stream to an airfoil by means of a prepared chart showing this evolution. The term "airfoil" was carefully explained. A simple airfoil was then made and demonstrated by blowing over the top of a piece of ordinary paper held in the hands. This

was repeated several times, and the word LIFT introducted. It was written on the blackboard.

8. It was now explained that the effects of air in motion may be duplicated at times in still air by having some object like an airfoil move swiftly through the air. This was demonstrated by a pupil who waved a large cardboard through the air—first, holding the handle attached to the cardboard horizontally—then, holding it at an acute angle to the direction of the motion. In the latter position the boy was unable to prevent the cardboard from lifting his arm.

9. The angle of the cardboard was then increased to 90° to show that when the angle is too great another effect is created. This is DRAG. The word was written on the blackboard and explained. The further effects of drag were dramatized by having a girl in a dancer's costume do a rapid pirouette. Then she attempted and failed to repeat her pirouette holding a large piece of cardboard in her arms. Finally, just to show she had not lost her touch, she pirouetted perfectly again withnot the cardboard.

10. It was pointed out that drag had to be overcome to a great extent before airplanes could attain their present-day high speeds. How this was done was shown through a series of experiments (recorded in motion picture film) on streamlining. The reel was run for about two minutes—just enough to show how a stream of CO_2 vapor behaves when it strikes a flat object, a round object, a tear-drop-shaped object, and a streamlined object. The commentary was given by the teacher while he watched the progress of the film on the monitor receiver.

11. The point was then made that drag is not always bad—that in fact it is sometimes very helpful. A toy parachute was blown into the air and its easy slow, descent noted. Reference was also made to the braking effect of drag used by pilots letting down their wing flaps when landing on the deck of a carrier.

12. The lesson was then summarized at the blackboard. Finally, the audience was told how to obtain references for further reading and research. A home reading assignment was suggested and the promise made that at the time of the next lesson the application of the ideas to controlled flight would be explained by a licensed pilot. (The United Air Lines had made this commitment.)

* * * * *

Now the announcer was making his closing remarks. The elapsed time was 25 minutes. It has taken several times longer to prepare this account of the lesson. The lesson itself took many hours to prepare. There was the time spent mobilizing materials; the telephone calls; the hours of rehearsal the previous Friday; the carting of materials * from place to place (the vacuum cleaner came from home, the manometer, the film, and the hemispheres from a school laboratory, the Venturi and other items from another source; the returning of these materials back again; and many other laborious and time-consuming details. Was it worth the effort? The messages of appreciation from those children at Sea View Hospital and elsewhere say, "Yes!" We think so too!

* *Apparatus and Materials Needed.* Magdeburg Hemispheres; study stand; mounted cover of the Saturday Evening Post, 10/20/51; three ring supports; five burette clamps; two round milk bottles; string; rubber tubing; large funnel; table tennis ball; large wooden spool; library card; pin; two round balloons; vacumm cleaner and hose attachment; manometer; ink; top of a Silex coffee pot; rubber dam; rubber band; glass connecting tubing; large rubber stopper with one hole; specially designed Venturi tube; manometer attachment tube; Evolution of Airfoil chart; large piece of paper from writing pad; stiff cardboard 2′ x 3′; stick on which to mount cardboard; cardboard 3′ x 5′; motion picture film "Streamlining"; toy parachute; copy of "Science of Pre-Flight Aeronautics"; blackboard; chalk; eraser; towel or rag; drinking glass; water.

DIRECT EXPERIENCE IN PHYSICAL SCIENCE FOR GENERAL EDUCATION

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In science education our first thought in regard to research is likely to be in terms of controlled experiments, such as Mendel's work with peas. We think in terms of a single, well-defined variable described in quantitative terms, seldom to the first decimal if the fifth will do. But because the ideal is not always attainable in practical situations, our thinking somewhat distorts or restricts what can be done in research. The investigations of Charles Lyell, Charles Darwin, and Michael Faraday may be taken as classical examples which show that, even though not reduced to well-defined, quantitative experiments, much can be accomplished through direct investigation in complex situations.

Lyell made first-hand observations along the coast of England and Scotland during his holidays, and he made a tour across the Alps and along the Mediterranean. Apparently his investigations involved no experiments, in the usual sense, yet his observations led to the publication of his *Principles of Geology,* a work that has revolutionized our thinking. Darwin's investigations were similar. Through observation Galileo discovered the moons of Jupiter and saw that they moved about the planet; his report substantiated the Copernican system. The essentials seem to be a direct investigation by whatever means possible, and then a report. Michael Faraday's experiments were relatively simple, straight-forward, and served their purpose well, though sometimes criticized in retrospect. Even today many worthwhile investigations do not fit the idealized pattern. Many illustrations may be found in nuclear research. Another example may be found in the May 29, 1953 issue of *Science*: The report cites archaeological evidence regarding recent changes in sea level along the New England coast. The evidence is based upon "critical examination" and analysis.

In curriculum work, the term "action research" is being used in reference to investigations in practical, organic situations. Stephen Corey has said:

> Anyone who tries to get better evidence of the success or failure of his teaching or administrative or supervisory activities, and modifies what he does in light of this evidence, is conducting a type of action research. (*Educational Leadership*, 7:149, December, 1949.)

I would add to this that a report is necessary if the method is to be considered scientific. Wherever teachers and school systems are willing to consider new ways of working, willing to try ideas that seem promising, the situation is experimental. Reporting is indispensable for progress. In science no research is accepted as conclusive until repeated successfully by other workers in the field. In education when something new is reported, if promising, it should be tried, then accepted or rejected, modified, and the new results also reported. In such a dynamic situation the quality of instruction will improve rapidly.

In general education some physical science courses have dispensed with laboratory work, because the traditional laboratory is considered unsatisfactory for the general student, perhaps even for the training of specialists. Yet in cultural courses too, learning is an active process, understanding based upon first-hand experience. The scientific method and attitudes, professed goals of instruction, are not developed through exhortation and analysis alone. Attitudes, interests, and skills are the product of a dynamic situation. Traditional laboratory manuals do not provide suitable experience, nor do the lecture-demonstrations of survey-type courses.

Organization and Conduct of the Course. What direct experience then is suitable for general education? For teacher training? At Wheelock College, a course in physical science has evolved from one modification after another in an attempt to meet this need. The course, a year's work of six semester hours, deals with five areas of knowledge: The weather, electricity, the sky, atomic energy, and the earth's changing surface. In the belief that direct investigation is fundamental to science and that the scientific method is desirable in modern education, great emphasis is placed on observation and interpretation of the immediate physical environment, yet stressing meanings that have general value. In a study of the weather, for example, the students keep a record of their observations. They interpret their observations and document the interpretations from the sources read. The interpretations are expected to show increasing insight. At first, perhaps, a student's interpretation of a cloud might be simply that clouds are tiny drops of water formed when warm, moist air is cooled. Later an interpretation might consider the possible cause of cooling and some of the broader implications, such as cirrus clouds being the leading edge of a warm front and indicative of an approaching storm. Ordinarily in education, direct experience is used as "audio-visual aids" to make reading and discussion meaningful, but in the physical science at Wheelock the relationship is reversed: The text, lectures, and discussions are designed to make the direct experience meaningful. The reference work is more purposeful, more functional; and rather than being eliminated, apparently is increased. Lecture-demonstrations and discussions are planned to develop logically the coherent concepts necessary for interpretations of the weather, but the presentation is modified in accord with the weather occurring at the time and in response to questions asked.

In studying the sky the students likewise interpret their observations, but interpretation is not limited to what can be seen with the eye alone. In fact, a major goal of the study is to learn how astronomers are able to determine motion, distance, and other facts not apparent to the naked eye. Other areas are studied in a similar way, with emphasis upon direct observation, experimentation. The experiences are practical for general students, yet organized to develop coherent generalizations considered significant in science education. In addition to the field reports, each topic is concluded with a comprehensive test, or in the case of the electricity, an informal oral report with demonstrations. The work is organized in terms of topics, rather than problems, to provide greater latitude for the individuals in solving their own real problems. The course develops basic principles of physical science, yet the social implications are stressed throughout. The organization encourages individual initiative while preserving the social stimulus of working together.

The students' own observations and interpretations are guided by the course outline, aided by comparatively numerous field trips with the class, by a list of reading references, by the lectures and discussions, and by a sheet of suggestions referred to as a *study guide*. Perhaps the study guide in one area will help to reveal the nature of the work, the content covered:

THE SKY

PROBLEMS FOR INVESTIGATION

1. How and why was astronomy the first science to develop? What did Copernicus do and believe? Kepler? Galileo? Newton? Aristotle? Ptolemy? What is a scientific method or attitude?
2. What are constellations? How did the stories develop? How are constellations used today by astrologers? By astronomers? Get acquainted with Orion and at least one other constellation, including the legends, the facts as known to astronomers, and the appearance as you see it. How do the stars appear to move with the hour, the season?
3. What is the Milky Way, and how is it like the Great Nebula in Andromeda? Locate these in the sky.
4. What is a gaseous nebula, a bright nebula, a planetary nebula, a ring nebula, a galaxy, a

Cepheid variable, a nova, binary stars, a red giant, a white dwarf? If possible, find an example of each and locate its position in the sky by actually observing it.

5. How does an astronomer use a telescope? What does a lens do? How does a reflecting telescope differ from a refracting telescope, and what are the advantages of each? Why is photography used?

6. How does color indicate temperature, composition, and motion of stars? How is a spectroscope used? A photometer? Note some actual stars and how their color appears to you. What does the color you see indicate? What does the brightness indicate?

7. What is light? What is a photon or quantum? The electromagnetic spectrum? Continuous, bright line, and dark line or absorption spectra?

8. What is the Doppler effect? Stellar evolution? The Red Shift?

9. How is distance determined through parallax and other means? Can you observe this?

10. How is the mass of a star determined? The diameter? The density?

11. What is the cause of day and night? Phases of the moon? Eclipses? Seasons? Tides? Observe and explain the apparent motion and phases of the moon each evening and from one day to the next.

12. What planets can you locate in the sky? Describe their appearance, and explain their apparent motion and the gradual change of position. How do Kepler's laws explain the motion of the planets? Newton's laws of motion and the law of gravitation? What evidence do we have that the earth is moving? The other planets? The stars?

13. What are comets? Meteors? What are the two types of meteorites?

14. How does solar time differ from siderial? Standard time? How can navigators determine longitude and latitude from the stars?

15. How do the planets compare in size, distance, and physical characteristics? Which planets can you observe? Where did you find them, and how did you distinguish them?

16. What are some of the significant facts which any theory regarding the origin of our solar system must take into account?

Direct experience is not practicable to as great an extent in the study of atomic energy, but as much as possible is provided through the use of radioactive ores, a Geiger counter, cloud chamber, and similar equipment in the classroom. The student papers interpret the news in this area and develop whatever themes may be significant to the student concerned, the theme being more or less the student's reaction, his understanding of the situation. Such is in accord with the general purpose of interpreting the student's own environment.

Study of the earth's surface ordinarily begins with a field trip to a nearby drumlin and to a quarry where Roxbury conglomerate is exposed. The trip demonstrates many features of glaciation, and observation of the conglomerate leads to the story of Old Appalachia, the erosion and uplift of the land, and other changes that have occurred in New England. Apparent also are joints, veins, weathering, and other features. The class work which follows is concerned with changes that have occurred in the land and the forces at work here. The emphasis is largely regional; rocks and fossils are used to illustrate the principles being developed. The content is drawn from both historical and physical geology, and conservation is stressed as it applies. Films and slides are used to illustrate features not otherwise readily observable. Another field trip is made to note the uniform sky line, the valley of the prehistoric Charles River, striations and other evidence of glaciation, the folding of the rocks, flow lines in igneous formations, an esker, and other features of the earth's changing surface. Laboratory work helps to gain familiarity with common rocks and minerals. The student's own field report, worked on concurrently with the foregoing class sessions, stresses observation and documented interpretations. The report may be an interpretation of familiar scenes, which may be quite local, may be a broad region, or perhaps a combination of the two. Many of the students come from other regions and prefer to interpret those areas, often with the help of home-town libraries, used during the spring vacation. The reports may stress the student's own interpretations, or may emphasize the information obtained from physiographies and similar references, but in any case must involve direct observation with descriptions and documentation. Many use photographs to picture the formations described. Rather

than working on a regional basis, some find illustrations of erosion, stratified rock, glacial erratics, the meandering of a stream, and other features being studied. Many collect common rocks and label them to illustrate their work, and a display is prepared in the classroom. The work seeks to develop broad meanings from interpretation of familiar scenes.

Student Opinions. Student evaluations indicate the course is considered interesting and worthwhile. A survey of the classes currently taking the course, or those who had it last year, reveals that in the annonymous opinions of the students the course does achieve its objectives, that the emphasis on direct investigation is successful; and the students are almost unanimous in stating that the course is not easy, nor merely time consuming, but challenging. Close documentation of reports is approved, but less emphatically, by the students in the present classes.

See below for the questions asked of the 108 students and the percentage response to those questions.

The answers to question 7 were stated in various terms but agree that the course is practical, encourages individual initiative, a scientific way of working. Some pointed out that the learning is based on actual experience; others commended the reference work. Some said the course deals with ideas rather than isolated facts.

There seems to have been no consensus in the responses to question 8. Many had no suggestion at all. Apparently the modifications made in response to previous student evaluations have met most of the criticisms that occur to students.

The most recent and most radical change was in the study of electricity. Previously

	Per Cent of Answers			
	Definitely Yes	To Some Extent	Very Little	Uncertain
1. Do you think the course in physical science is successful in your own cultural development?	70	29	1	
2. Do you think the course will help you as a teacher?	75	21	3	1
3. Specifically, does the course achieve its objective to develop your ability to interpret your own environment?	61	34	5	
4. Does it help to develop a scientific approach to common problems, a desire to investigate?	45	44	11	
5. Does it help to achieve an appreciation of science in our lives today, an interest in science?	46	48	6	
6. Does it help to develop the skills needed in everyday life, or skills needed by elementary school teachers?	52	39	8	1
7. What are the three most distinctive features of the course?				
8. What is the greatest weakness of the course; that is, what would you like changed?				
9. Are the field reports effective as a method of study?	65	31	3	1
10. Was the laboratory method in electricity effective?	69	25	6	
11. Is the stress on reference work and close documentation effective in gaining functional reading?	39	45	12	4
12. Is the course: a. Overwhelming in difficulty?	4			
b. Challenging?	86			
c. Not hard, but time consuming?	10			
d. Easy?	0			

the lecture-demonstrations were overwhelming to many students. The variations in background made lecturing difficult: Some had a background of physics in high school and perhaps other experience with radio sets and other electrical devices. At the other extreme, some had almost no direct experience with electricity, were afraid to touch a dry cell for fear of electric shock, and some assumed the button switches, familiar beside front doors, are actually door bells. Verbal knowledge was often greater, but for most their direct experience had been limited to observation of teacher demonstrations. In the short four-week period available to the study it seemed that laboratory work would be the most valuable experience the students could have. So it was decided to use a radically different approach. With but a brief introduction, the students were turned loose with a variety of equipment to investigate for themselves. Reference work and a study guide provided some suggestions, but each student was told to follow his curiosity in a coherent manner, the solution of one problem leading on to other questions, further investigation, much as a scientist works on original, more advanced problems. Each individual kept a record, a description of the investigations made and the results obtained, not generalized or idealized, but exactly as observed. Reference work helped to avoid superficiality, and the interpretations were closely documented from the references used. Applications and social implications were stressed in the interpretations. A variety of equipment was available, mostly single items of a kind. Where students worked together it was but for a limited time while two or more were interested in the same piece of equipment, but even there the descriptions kept and the reference work done were individual. At first the instructor was kept busy giving aid, but the students became increasingly independent as the work progressed. In addition to the written reports, the work was concluded with oral reports and student demonstrations. The reporting was informal, everyone who worked with magnetic induction, for example, demonstrating and reporting at the same time with the give and take of an impromptu panel discussion. Accordingly repetition was avoided, and the reporting was stimulating, rather than tedious as reporting is likely to be. The student evaluations, the written reports, and the general reaction indicate the learning was greater than before, more functional, and productive of constructive attitudes. A few of the students in the present evaluation have suggested a more thorough introduction before beginning the individual investigations in electricity.

The student evaluations include some revealing comments:

"I have learned that actual experimentation is the best way to solve a problem. Reading will help, but until you have tried it yourself, you really haven't learned." "I have developed an attitude of questioning more than merely accepting." "I like getting out and observing the actual environment, experimenting by ourselves." "I like the combination of the lectures, plus field reports, and being able to experiment for ourselves, draw our own conclusions." "We are more independent; the course is more colorful. We discuss interesting topics which apply in everyday life." "We gain knowledge and confidence along with added interest. One does not learn by memorizing, but instead by actual, personal experience. This course has been very enjoyable to me this year. I have never enjoyed science before and find this year very beneficial." "I like the way we covered so many different fields so well, the way we did so much scientific experimenting, the way we wrote papers and had tests as a means of evaluating." "I would never take a course in atomic energy, for example, but now that I have a general background, I understand the reports on the radio and in the newspapers."

"On trips this summer I found myself observing the surroundings with more

knowledge and enjoying that knowledge. I still like to point out some of the stars and constellations I learned last year." "I can now sympathize with the weather forecasters." "This summer I went on a trip through the Rocky Mountains. I was able to appreciate them more after taking the physical science course." "After studying about geology, I drove to New York and through the Adirondacks, and I was much more aware of the rock formations and their meanings." "Electricity . . . helped me in overcoming my fear of it." "I find that daily I am finding answers to problems that previously perplexed me." "I now find myself understanding and looking more at my surroundings." "All the work is well organized. We cover the material quite thoroughly." "I like the individual, independent investigation, *doing* along with intellectual pursuits." "Asking questions pertaining to the subject in class is of benefit to others as well." "It helps you to think for yourself and learn by observation and reading." "Before taking these courses at Wheelock, I disliked even the word *science* Now, by understanding what science actually is and how it is not isolated to a test tube, I have become most interested in it myself and in helping others to become interested." "I'm more aware of our social and economic problems. I realize the importance of science in the school curriculum." "Yes, I detested science in school, but I have definitely enjoyed it and gained knowledge from it here in college."

CONCEPTOGRAMMATIC MATERIALS IN THE TEACHING OF ELEMENTARY SCIENCE

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HIEROGLYPHICS, the sacred carvings of the ancient Eygptians (about 3000 B.C.), are perhaps the first attempt by man to represent ideas by pictures.[1] By careful arrangements of symbolic engravings important concepts were expressed. With refinement that eventually comes with adaptation and growth of knowledge, phonetic sounds were combined with these engravings to produce *phonograms,* i.e., pictures that represent sounds.

An ancient Chinese spoke with wisdom when he so adequately stated, "One picture is worth a thousand words." For if we were to examine the Chinese language we would discover that it is composed of approximately 40,000 characters each of which expresses a specific idea.[2]

Many other symbolic inventions evolved before language as we now know it developed. Language, concepts, and reasoning are closely interrelated.[3] Although reasoning may occur without language it may not proceed as rapidly without previous products of thought (concepts).[4] Concepts thus play an important role in thinking for they are the results of previous experiences and when expressed symbolically are the keys to further thought processes.[5]

Concepts are developed by abstraction and generalization.[6] Abstraction being the realization that different *objects* bear similarities and generalization being the realization that an object never before observed has characteristics similar to something known.

[1] T. Walter Wallbank and Alastair M. Taylor, *Civilization—Past and Present,* 1:42.
[2] *Ibid.*, p. 96.

[3] John Dewey, *How We Think*, pp. 170–187.
[4] *Ibid.*, pp. 173–175.
[5] W. Edgar Vinacke, "The Investigation of Concept Development," *Psychological Bulletin*, 48:1–34, January, 1951.
[6] Norman L. Munn, *Psychology*, p. 82.

Our problem as science teachers, then, is to devise and develop symbolic means of aiding our pupils in efficient concept formation, i.e., to combine familiar symbolized concepts with unfamiliar concepts in a fashion that will improve the learning situation.[7] Let us examine the available literature and attempt to discover any materials that may be useful toward this end.

SURVEY OF THE LITERATURE

A survey of the literature reveals that little research has been done in the area of the relationship between science concept development and drawing in young children.[8] There are many articles about concept development in children, but few deal with science concept development.[9] Numerous articles have been published describing the type of drawing to use in science instruction on the secondary school level.[10] However, there has been very little experimentation regarding the ability of children of different ages to identify pictured objects.[11]

Malter tells us from a review of six previous studies that investigators now have enough information available to understand the nature of the diagram, and how a teacher may properly utilize and construct diagrams.[12]

Abramson by using pictorial ideographs observed an increase in the student's ability to obtain and retain concepts about elementary mechanics.[13]

Haupt examined many student-made drawings and hypothesized that the inclusion of concepts in a drawing will aid learning.[14]

Silano by using a semirepresentative, systematic type drawing method, had success in teaching aeronautical concepts to elementary school children.[15]

There is disagreement among the various authors as to the definitions of terms used in drawing and in the type of drawing to use in the learning situation.

One author calls picture photographs, cartoons, charts, or diagrams *pictorial ideographs.*[16] In another source pictorial ideographs are referred to as *graphic materials* and include maps, charts, diagrams, posters, cartoons, and graphs.[17]

Ayer has referred to the analytical and representative type drawings.[18] Let us be sure we know what these terms mean. An analytical drawing consists of a diagrammatic description of scientific phenomena. It includes cross-sections, outlines, x-ray drawings, process diagrams, and many others. Representative drawing of scientific phenomena presents the object as it actually appears to the observer. This brings in considerations of length, width, and height. Research on the representative type drawing indicates that it is not beneficial as a learning device in the teaching of science.[19]

CONCLUSIONS AND SUGGESTIONS

The supplementary incorporation of science concepts in drawings will aid the learning of science in the elementary school. In order to state this hypothesis, the au-

[7] *Ibid.*, pp. 184–186.
[8] Alfred A. Silano, "The Drawing as a Learning Aid in Science," *Science Education*, 34:51–55, February, 1950.
[9] Listed in bibliography.
[10] Listed in bibliography.
[11] Morton S. Malter, "Children's Ability to Read Diagrammatic Materials," *The Elementary School Journal*, 49:98, October, 1948.
M. D. Vernon, "The Development of Imaginative Construction in Children," *British Journal of Psychology*, 39:102–111, December, 1948.
[12] Malter, *Ibid.*, p. 102.
[13] Bernard Abramson, "A Comparison of Two Methods of Teaching Mechanics in High School," *Science Education*, 36:96–106, March, 1952.
[14] George W. Haupt, "Evaluation of Student's Scientific Drawings," *Science Education*, 24:61–63, January, 1940.
[15] Silano, *op. cit.*, pp. 51–55.
[16] Abramson, *op. cit.*, p. 97.
[17] Carter V. Good, *Dictionary of Education*, p. 190.
[18] Fred C. Ayer, "The Psychology of Drawing with Special Reference to Laboratory Teaching," *Investigations in the Teaching of Science*, pp. 37–39.
[19] *Ibid.*, p. 38.

thor must assume that there is a relationship betwen science concept development and drawing in young children.[20]

Information gathered by the author from research concerned with the use of drawing in secondary school science teaching seems to support this hypothesis. It is apparent, however, that research in this area is lacking on the elementary school level, particularly on various levels of intelligence.

In the search for a practical application of these beliefs many questions arise. What elementary science concepts may be represented by drawings? Can diagrammatic materials be used to express science concepts to young children? Are young children capable of reading and interpreting diagrammatic materials, and if so, what happens to them? How will a child represent science concepts in his own drawings? A great fund of information must be collected relative to these questions.

In order to bring unity to educational science drawing, the author offers a generalization. This would be to call all means *of representing scientific phenomena* (in a learning situation) by drawings a *conceptogrammatic* presentation. The underlying assumptions here are that all pictorial representations express some concept, and that the inclusion of a concept in a drawing aids learning.

A *conceptogram* or a *conceptogrammatic* drawing is based on the conceptual value of a drawing. It is not necessarily founded on artistic ability, but upon the quantity and quality of concepts expressed within and surrounding the drawing. Every *conceptogram* must be properly labeled to insure that the phenomena are described accurately. Symbols such as alphabetic letters, numerals, arrows, and dotted lines are used freely to clarify the interpretation of the *conceptogram*. The outline presented below is by no means indicative of all the available or possible *conceptogrammatic* materials.

CONCEPTOGRAMMATIC MATERALS

A. Analytical
   1. Diagrams.
      a. Cross-sections.
      b. Longitudinal sections.
      c. Process drawings.
      d. Graphs.
      e. Charts.
B. Representative.
   1. Pictorial ideograms.
      a. Illustrations.
      b. Photographs.
      c. Artistic types.
      d. Cartoons.

Every elementary school science teacher who has ever produced an original drawing upon the blackboard or who has prepared in the form of a picture chart some means of describing scientific principles, has in effect developed skill in constructing *conceptograms*. The teacher must remember that the *conceptogram* is merely a symbolized idea and that its value as a learning aid will be dependent upon his ingenuity in devising and using it. Care should be taken not to use the *conceptogram* in elementary science teaching below the age of eleven years. According to Vernon, children above this age level with normal intelligence and emotional maturity are able to interpret and understand pictures more fully.[21] Below eleven years of age the children in Vernon's study merely enumerated or gave simple descriptions of pictures, neglecting meaning.[22]

Conceptogrammatic materials may be used in many ways to teach elementary science. The author does not think that the *conceptogram* will become the panacea of elementary science instruction. He does believe that if used in conjunction

[20] Sina M. Mott, "The Development of Concepts" (A Study of Children's Drawings), *Pedagogical Seminary,* 48:199, 1936.

[21] Vernon, *op. cit.*, p. 102.
[22] *Ibid.*, p. 102.

with other learning aids, it will help to give clarity and depth to children's thinking.

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AN INVESTIGATION OF TEACHER-RECOGNIZED DIFFICULTIES ENCOUNTERED IN THE TEACHING OF SCIENCE IN THE ELEMENTARY SCHOOLS OF FLORIDA *

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THIS study is the result of an investigation conducted in Florida to determine what factors, in the opinion of the classroom teachers, handicap the teaching of science in the elementary school; to find what, if any, relationship exists between the aspirations of teachers and the difficulties they think they face.

The study was made (1) by means of a survey questionnaire of a ten per cent stratified random sample of all Florida teachers; (2) by an interview of a limited sample of these teachers; and (3) by observations and discussions in certain teaching situations.

Since a number of the questionnaires distributed were not returned, statistical tests were applied to the data, which indicated that the respondees and non-respondees may be considered as samples drawn from a homogeneous population with respect to certain characteristics.

In order to test the reliability and validity of the questionnaires a modification of the split-half process was used (see *Statistics in Psychology and Education*, by Henry E. Garrett, pp. 382–383). On the basis of this test the hypothesis of zero correlation (which implies the questionnaires were filled out randomly) was rejected—other techniques were utilized, such as logical validation and pre-testing and interviews, all of which showed evidence of consistency.

The following table is a composite of excerpts from the numerous tables in the study, which show questions—arrayed according to categories—most frequently marked by the respondees for difficulties encountered in the teaching of science in the elementary schools.

In the table (p. 441) the checks under the heading "75 per cent or More—Some or Serious Difficulty" represent a summation of responses on the questionnaire given in both the "Serious Difficulty" and the "Some Difficulty" columns.

This percentage treatment gives a picture of the difficulties most frequently checked by teachers.

The raw data showed that the category of physical facilities had the highest frequency of occurrence and ranked first among the recognized difficulties of teachers. Methods and techniques ranked second, resources, materials, and equipment a close third, field trips, fourth, content, subject matter, and area of experience, fifth, and library facilities, sixth, and others.

Statistical procedures such as percentages, comparison of frequencies, chi-square, and coefficient of correlation were used throughout the study. It is evident from the analysis of findings that factors influencing science teaching are interrelated and somewhat different in dissimilar situations. Difficulties limiting science teachings may be attributed to multiple causation. However, the pattern that emerged from the analysis revealed certain limiting elements that are common and more generally widespread.

In the nine categories of difficulties, there was general agreement among all of the respondees that "physical facilities" was the category of greatest difficulty. This fact

* Based on the author's doctoral study by the same title completed at the University of Florida, Gainesville, Florida, 1954.

DISTRIBUTION OF TEACHERS BY PER CENT CHECKING ITEMS UNDER CATEGORY OF DIFFICULTY

Category of Difficulty	75 Per cent or More— Some or Serious Difficulty	25 Per cent or More— Serious Difficulty	50 Per cent or More— Serious Difficulty
Difficulties Related to Curriculum			
Reducing the number of pupils in the class to enable science teaching	..	X	..
Obtaining longer periods of science teaching	..	X	..
Difficulties Related to Library Facilities			
Procuring supplementary science books at appropriate grade levels	..	X	..
Obtaining an up-to-date and usable bibliography	..	X	..
Difficulties Related to Resources, Materials, Equipment, Consultants			
Obtaining special science materials and equipment (such as magnets, batteries, wire, compass, etc.)	..	X	..
Finding suitable demonstration materials	..	X	..
Procuring funds for materials	X	X	X
Preparing teaching aids, or knowing how to improvise materials (making things such as star box, weather equipment, etc.)	..	X	..
Finding places where natural physical principles may be illustrated (i.e., gullies, quarries, weather station, etc.)	..	X	..
Difficulties Related to Field Trips, Excursions, Walks			
Availability of funds for excursions	..	X	..
Transporting of children to designated areas	..	X	..
Difficulties Related to Methods and Techniques			
Helping the child discover facts for himself, rather than telling him the answer	X	..	..
Helping children apply principles	X	..	..
Difficulties Related to Content, Subject Matter, Area of Experience			
Adapting technical science information for use with children	X	X	..
Difficulties Related to Physical Facilities			
Obtaining and keeping:			
A sufficiently large room	..	X	..
Adequate bulletin boards, exhibit tables, display space	..	X	..
Counter shelf, or table, for cages, aquaria, terraria	..	X	..
Work tables instead of traditional fastened-down chairs	..	X	..
Convenient source of water	..	X	..
Convenient source of heat	..	X	..
Place to prepare science materials	X	X	X
Storing materials conveniently and adequately	X	X	..
Developing system for storage	..	X	..

was further verified during interviews and classroom observations. Teachers were attempting to teach pupils in obsolete, overcrowded, and unequipped classrooms. The lack of utilities presented a further handicap. This discouraged many teachers from engaging in activity programs of any kind.

The majority of teachers were weak in the methodology of science teaching. Little concern is given to developing elements of the scientific method and to building attitudes, although many are conscious of it. Some, however, expressed surprise that it could be done. Many teachers had difficulty in the selection of content and interpreting it to children. Over 75 per cent of the teachers had difficulty helping the child discover facts for himself—rather than telling him the answer—and helping children apply principles. All of this indicates a need for the adequate preparation of teachers. There is a decided weakness in the method of presenting science to children, science activity work, and in the creation of an atmosphere conducive to science learning in the classroom. Other aspects of the problem, such as conservation, gardening, and current science, are being sorely neglected. The physical sciences, too, are not being taught to any extent.

Effective science teaching requires adequate materials and equipment. There were little or no materials provided for teachers —nor funds with which to purchase them. Many had little idea of what was required. They also indicated that lack of storage space precluded the use of such materials, since keeping them would involve difficulty. Few were availing themselves of resource opportunities in the community.

About 70 per cent of the teachers had difficulty procuring funds or transportation for excursions. The element of risk, a fear of living things, large groups of children and liability for them, and community disapproval—these factors discouraged teachers from taking children on trips.

Lack of time was consistently mentioned as a great barrier to science teaching. It would appear that the mention of time is a rationalization for either lack of "know-how" or lack of conviction of what is important in the curriculum.

Emphasis on reading and the language arts took priority over all the curricular offerings in the school program, including science. There was some incidental science teaching, very little planned science teaching; and many teachers depended on other agencies, such as 4-H clubs, gardening clubs, and the like to provide science experiences for children. The most frequently used method of teaching science was to have children read science books. Nearly 75 per cent of the teachers had difficulty procuring supplementary science books for children at appropriate grade levels.

Many of the science books—in the schools fortunate enough to have them—were of the more contemporary series type. Teachers would invariably complain of children's reading difficulties with them. They were usually too advanced. More than half the teachers using the modern readers hoped for better grade placement of reading materials. A large number of teachers asked where books giving specific non-technical information on subject matter could be located.

Some personality traits possessed by teachers were retarding influences to science teaching. Over 50 per cent lacked confidence in performing demonstrations, in doing experiments, and in dealing with living things.

Many principals of schools adopted a laissez-faire attitude towards teachers and did little to encourage science teaching; but it was felt by many of the respondees that the principal could be influential in enchancing the science program. The principals considered lack of preparation and lack of interest on the part of teachers as a weakness in the science program. They also indicated that the lack of materials and equipment, and time limited the teaching of science.

Some conditions inherent in the environ-

ment were pointed out as affecting science teaching. Tourists' children presented factors of difficulty in orientation to classrooms, but there was divided opinion on this point. Migrant workers required Spanish-speaking teachers, and the emphasis was on the communicative skills in the curriculum, leaving little time for science.

Socio-economic conditions of some groups gave emphasis to homemaking in the curriculum; and emotional problems of children who came from split homes gave emphasis to mental hygiene.

Truancy was the concern of school authorities in one area, to the exclusion of curriculum enrichment; and in many areas, because of high rents, low salaries, poor housing, frontier conditions, or other factors, qualified teachers were difficult to hold.

The aspiration levels of teachers were explored and compared with factors that the writer thought might affect the day-to-day teaching of science in the elementary school. It appears that teachers tend to teach more science if they have high aspirations. However, the difficulties or obstacles that teachers encounter in the teaching of science are the same regardless of their aspirations. There is no difference in the aspirations of men and women. Such factors as age, degrees, certificates, or salaries do not markedly make a difference in the aspirations of teachers.

In the teaching of science in the elementary school, there appears to be a wide gap between theory and practice. Although this divergency may be due, in part, to the kind of curriculum organization, it is possible to effect change within existing frameworks and make science an integral part of the school day.

The inclusion of science in the classroom is related in great measure to the degree to which science experience is valued by the principal, the teacher, the pupils, and the community. This relationship is high when the significance of science in the role of education is understood by those concerned with the child's development.

There is general agreement as to what teachers think are factors limiting science teaching in the elementary school. There is also evidence of difficulties that are real to the teacher but could be overcome through better understanding of science and how to teach it. On the other hand, there are difficulties hampering science teaching over which the teacher has little or no control; but if he had sufficient interest, resourcefulness, and high aspirations, he could effect change in the curriculum.

There is conflict among many conscientious teachers as to content emphasis. This focus is determined in large measure by the teacher's individual interest and competency, administrative pressure, compulsory pupil achievement (namely in reading in the lower grades), and environmental conditions. These factors, occurring singly or in combination, make a difference in what is taught. But more basic, perhaps, is the teacher's conviction of what is important in the curriculum and in the lives of boys and girls.

THE ESTIMATION OF SCIENCE INTERESTS AND THEIR USE IN CURRICULUM CONSTRUCTION

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VARIOUS devices are in use for determining interests. Outstanding among these are the "Strong Vocational Interest Blanks" [1] and the "Kudar Preference Record." [2] These inventories offer us an opportunity to determine general interest patterns but are limited in value if they are to be used to locate specific interests within a single subject area.

Various educators and educational psychologists have indicated that interests are expressions of "things one needs to know" in order to solve life problems. Linton, for example, states that "anything which directly affects the well-being of a society can hardly fail to attract the attention of its members and thus to become an interest." [3] Laton and Bailey point out that sex interests as evidenced by questions asked by young people are actually expressions of the problems which these people will have to solve.[4] In a discussion of certain science courses which were given to adults on a voluntary basis, Flood and Grassland point out that the strongest motive for attending these courses was to obtain an understanding of the present world.[5] In an investigation of the interests of college students in the area of Biology, Davies finds that students are interested in topics which have direct application to themselves.[6] Heaton points out that the educational psychologist emphasizes that a student will exert his greatest effort and learn with least difficulty when he is pursuing his interests.[7] It would, therefore, seem desirable that in course construction consideration be given to the interests of students in the course.

There is at present no comprehensive interest inventory for determining science interests. In this paper we shall describe a method which was employed to estimate the science interests of a group of college students. A questionnaire was constructed in which the intent was to determine the degree of interest which students in a science survey type course had in the various science area covered in the course.

The complete questionnaire has been previously reported.[8] The portion of the questionnaire which is particularly relevant to this paper consisted of a listing of 150 common science terms all of which were used in the science survey course. The questionnaire was administered to each student at the conclusion of the course. In this way it was felt that all students would be familiar with the terms and would recognize the subject area in which the term was discussed in the course. A copy of these terms along with the instructions given to the students follows:

In the following lists of words you are asked to indicate your degree of interest in the subject

[1] E. K. Strong, Jr., *Vocational Interests of Men and Women.* Palo Alto: Stanford University Press, 1943.

[2] G. F. Kuder, *Manual to the Kuder Preference Record.* Chicago: Science Research Associates, 1939, 1946.

[3] Ralph Linton, *The Study of Man.* New York: D. Appleton-Century, 1936.

[4] Anita D. Laton, and Edna W. Bailey, "Sex Responsiveness Mating and Reproduction," *Monograph No. 2, Bureau of Educational Research in Science.* New York: Bureau of Publications, Teachers College, Columbia University, 1940.

[5] E. E. Flood, R. W. Grassland, "Origins of Interests and Motives for Study of Natural Sciences and Psychology Among Adults," *British Journal of Educational Psychology,* 18:105–17, June, 1948.

[6] P. A. Davies, "College Students' Interest in Biology," *Journal of Educational Research,* 17: 64–77, February, 1947.

[7] K. L. Heaton, *A College Curriculum Based on Functional Needs.*

[8] W. Leader, "Expressed Science Interests of Students and Their Relationship to Achievement," microfilm copy, Ph.D. dissertation, Columbia University Library, New York, 1951.

area in which that word would normally be found in a science course. You are asked to give one of three ratings to the word: Interested, very interested, or not interested. If your reaction to the word is one of indifference draw a line through the word.

Indicate very interested by 2 check marks, interested by one check mark and not interested by a figure 0.

Example:

0 carbon
√√ sunspot
√ plasma

This would indicate that you were very interested in the subject area in which sunspots are discussed, mildly interested in the subject area in which plasma is discussed, not interested in the subject area in which carbon is discussed, and indifferent to the subject area in which heterodyne is discussed. Now turn the page and mark each word.

______infra-red	______scurvy	______vitamins	______quartz
______clouds	______Mars	______pound	______inertia
______Cenozoic	______nebula	______piston	______temperature
______satellite	______big dipper	______volcano	______gene
______X-ray	______lava	______pulley	______moon
______excretion	______wave length	______thyroid	______planet
______proteins	______humidity	______assimilation	______protozoa
______heredity	______Milky way	______rock	______refraction
______liter	______opium	______nucleus	______unicellular
______winds	______microbe	______fertilization	______irritability
______Pleistocene	______chloroplast	______wedge	______vestigial
______narcotic	______ovary	______acid	______elements
______chlorine	______stem	______oxygen	______dinosaur
______embryo	______hydroxide	______Venus	______electricity
______halogens	______potential	______Radio	______constellation
______telephone	______earthquake	______motor	______steam
______cytoplasm	______blood	______copulation	______germ
______eclipse	______gamma ray	______urea	______electron
______sedimentary	______epidemic	______metamorphic	______era
______generator	______kinetic	______endocrine	______salt
______magnet	______urethra	______Bromine	______galaxy
______absorption	______osmosis	______engine	______sextant
______endocrine	______epoch	______nerve	______flower
______drug	______centimeter	______fronts	______vagina
______chlorophyll	______stars	______cell	______obstetrics
______chemical	______gravity	______voltage	______rain
______thermometer	______ice berg	______fats	______mineral
______mold	______response	______bacteria	______chromosome
______heat	______armature	______telegraph	______proton
______riboflavin	______lodestone	______repel	______urine
______carbohydrate	______pitch	______frequency	______petals
______adrenalin	______igneous	______magnet	______photosynthesis
______leaf	______prism	______equinox	______light
______hemoglobin	______penis	______weather	______lever
______longitude	______solstice	______seasons	______atom
______acceleration	______paramecium	______petunia	______evolution
______anemia	______glacier	______current	______energy
______reproduction	______root		

The number of words chosen for the inventory from each area of science was in approximate proportion to the time devoted to that area in the course. The following selections were made in an initial determination of which words to use.

20 words from the area of biology
13 words from the area of physics
4 words from the area of chemistry
5 words from the area of geology
5 words from the area of astronomy
3 words from the area of meteorology

It should be recognized that these areas are not independent of each other and that words selected in one area might be discussed in any of the other areas. They were however discussed particularly with reference to a specific subject field. The original series of words was given to the other instructors in the survey course and after some additional deletions and some additions, a final list was agreed upon.

For each word a pair of words was also

TABLE I

NUMBER OF CHECK MARKS RECEIVED BY EACH WORD FROM GROUP OF 101 STUDENTS IN SURVEY COURSE AND THE RANK OF EACH WORD IN THE SERIES OF 50

	Original Series	No. √s	Rank	Second Series	No. √s	Rank	Third Series	No. √s	Rank
1.	anemia	112	10	blood	135	3	hemoglobin	104	8.5
2.	assimilation	66	40	absorption	64	38	osmosis	69	30
3.	carbohydrate	73	36	protein	82	27	fats	63	39
4.	chlorophyll	77	35	photosynthesis	64	38	chloroplasts	59	43
5.	dinosaur	112	10	evolution	151	2	vestigial	49	47.5
6.	fertilization	137	3	reproduction	173	1	copulation	125	2.5
7.	gene	139	2	chromosome	113	7	heredity	166	1
8.	irritability	86	32	nerve	118	5.5	response	110	6
9.	narcotic	108	13.5	drug	108	10.5	opium	107	7
10.	protozoa	62	42.5	paramecium	59	42	unicellular	49	47.5
11.	urea	87	29.5	urine	97	14	excretion	96	15
12.	vitamins	112	10	scurvy	83	26	riboflavin	61	41
13.	fungus	..	..	mold	62	41	bacteria	99	12
14.	cell	84	34	nucleus	86	22.5	cytoplasm	77	27.5
15.	endocrine	119, 110	6	thyroid	111	8.5	adrenalin	118	4
16.	epidemic	103	18	germ	118	5.5	microbe	85	20.5
17.	embryo	152	1	obstetrics	111	8.5	ovary	125	2.5
18.	penis	118	7.5	vagina	130	4	urethra	102	10
19.	root	52	45.5	stem	43	48	leaf	53	45.5
20.	flower	58	44	petals	42	49	petunia	29	50
21.	centimeter	30	48	pound	31	50	liter	42	49
22.	lever	52	45.5	wedge	50	45	pulley	57	44
23.	energy	106	15	kinetic	69	33.5	potential	64	37.5
24.	gravity	102	20	inertia	71	32	acceleration	68	31.5
25.	thermometer	71	38	temperature	86	22.5	heat	80	24.5
26.	engine	103	18	steam	77	29.5	piston	92	18
27.	pitch	62	42.5	frequency	77	29.5	wave-length	75	29
28.	light	97	21.5	prism	64	38	refraction	66	35.5
29.	motor	94	24.5	generator	81	28	armature	68	31.5
30.	current	85	33	electricity	108	10.5	voltage	81	23
31.	telegraph	88	27	telephone	94	16	radio	96	15
32.	x-ray	120	5	gamma-ray	89	18.5	infra-red	101	11
33.	atom	118	7.5	electron	92	17	proton	80	24.5
34.	oxygen	94	24.5	chemical	68	35	elements	94	17
35.	acid	68	39	hydroxide	49	46	salt	67	33.5
36.	halogens	45	47	bromine	48	47	chlorine	62	40
37.	magnet	87, 94	29.5	repel	56	44	lodestone	64	37.5
38.	clouds	103	18	weather	95	15	rain	83	22
39.	winds	97	21.5	fronts	74	31	humidity	79	26
40.	rock	63	41	mineral	64	38	quartz	53	45.5
41.	metamorphic	72	37	igneous	64	38	sedimentary	66	35.5
42.	glacier	87	29.5	ice-berg	84	25	pleistocene	104	8.5
43.	earthquake	122	4	volcano	98	13	lava	77	27.5
44.	era	92	26	epoch	88	20	cenozoic	112	5
45.	galaxy	95	23	milky-way	86	22.5	nebula	86	19
46.	planet	108	13.5	Mars	102	12	venus	96	15
47.	seasons	87	29.5	solstice	58	43	equinox	60	42
48.	latitude	..	..	longitude	69	33.5	sextant	67	33.5
49.	moon	104	16	satellite	89	18.5	eclipse	97	13
50.	stars	109	12	constellation	86	22.5	big-dipper	85	20.5

Range 30–152 Range 31–173 Range 29–166

using formula

$$R = 1 - \frac{6 \quad D^2}{N\,(N^2 - 1)}$$

r between 1st and 2nd series = .729

r between 2nd and 3rd series = .725

r between 1st and 3rd series = .620

TABLE II

SERIES OF FIFTY TERMS FROM THE AREA OF SCIENCE ARRANGED IN THE ORDER OF THEIR INTEREST RANK AS DETERMINED FROM THE RESPONSES OF 101 STUDENTS IN A SCIENCE SURVEY COURSE

Rank	Word	Science Area in Which the Word Would be Found	No. of Checks Received
1	embryo	Reproduction	152
2	gene	Inheritance and descent	139
3	fertilization	Reproduction	137
4	earthquake	Geology	122
5	x-ray	Physics	120
6	endocrine	Response systems	119
7.5	nerve	Response systems	118
7.5	penis	Reproduction	118
9.5	anemia	Circulation, nutrition and metabolism	112
9.5	dinosaur	Inheritance and descent	112
11.5	drug	Disease and Health	108
11.5	planet	Astronomy	108
16	Moon	Astronomy	104
14	epidemic	Disease and health	103
14	engine	Physics	103
14	clouds	Meteorology	103
17	urine	Circulation, nutrition and metabolism	97
18	galaxy	Astronomy	95
20	motor	Physics	94
20	telephone	Physics	94
20	oxygen	Chemistry	94
22.5	electron	Physics	92
22.5	era	Geology	92
24	glacer	Geology	87
26	nucleus	Physics	86
26	temperature	Physics	86
26	constellation	Astronomy	86
28	current	Physics	85
29	scurvy	Circulation, nutrition and metabolism	83
30.5	chlorophyll	Botany	77
30.5	frequency	Physics	77
32	fronts	Meteorology	74
33	carbohydrate	Circulation, nutrition and metabolism	73
34	metamorphic	Geology	72
35	inertia	Physics	71
36.5	longitude	Astronomy	69
36.5	kinetic	Physics	69
38	acid	Chemistry	68
39	assimilation	Circulation, nutrition and metabolism	66
40	prism	Physics	64
41	rock	Geology	63
42.5	protozoa	Basic biology	62
42.5	mold	Botany	62
44	solstice	Astronomy	58
45	repel	Physics	56
46.5	lever	Physics	52
46.5	root	Botany	52
48	halogens	Chemistry	45
49	petals	Botany	42
50	pound	Physics	31

found which would parallel or be almost a synonym for the original word. For example the first word on the original list was anemia. This word would be discussed normally in the same context as the words "blood" and "hemoglobin." The second word was "assimilation." "Absorption" and "osmosis" were selected as the pair of words which would correspond. The third word was "carbohydrates." "Proteins" and "fats" were included as words which were fairly equivalent in significance and would appear in the same discussion. This procedure was repeated for each of the 50 words until a list of 150 words was assembled. These words were then put into a random order and included in the inventory. Responses made by 101 students taught by the author were tabulated. This group composed three sections of students in the survey course. Comparable data was obtained from 11 other sections of the course taught by 4 other instructors. Sample data from these other sections was previously reported and showed considerable consistency with the data obtained from the responses of this group. The following data refer to this group.

For each word a count was made of the total number of checks given to it on all 101 papers. The words were then sorted into the series to which they belonged, i.e. original series, second series and third series. The words in each series were arranged in order on the basis of the number of checks received. The tabulation of this will be found in Table I. The total number of checks which a word could possibly receive was 202. A word's rank indicates the relative interest value of that word. By comparing the rank of each word of the related three words we obtain a value indicative of the reliability of the responses of the group. By applying the rank order formula $\left(r = 1 - \frac{6(\quad d^2)}{N(N^2-1)}\right)$ and using the relative rank of the word in the series as the criteria for comparison, a correlation of .729 was obtained between ranks assigned to the first and second series of words. A correlation of .620 was obtained between ranks assigned to the first and third series of words and a correlation of .725 was obtained between ranks assigned to the second and third series of words. (Table I.)

Table II shows the original series of words arranged in the order of rank according to the number of check marks received. The table also shows the particular subject area from which the word was derived.

An analysis of the data found in Table III reveals the relative interest students in the survey course expressed in the major science areas found in the course. These can be better interpreted if we use a single scale for comparison. This can be accomplished by considering the per cent of checks of one subject as a frequency value and the interval in which that per cent occurs as a score value. In Table III we have used six

TABLE III

RELATIVE POPULARITY OF AREAS OF SCIENCE FOUND IN A SCIENCE SURVEY COURSE AS DETERMINED FROM THE RESPONSES OF 201 STUDENTS TO 150 SCIENCE TERMS

Science Area	Total No. of Terms in Series of 150	1–25 No.	1–25 %	25.5–50 No.	25.5–50 %	50.5–75 No.	50.5–75 %	75.5–100 No.	75.5–100 %	100.5–125 No.	100.5–125 %	125.5–150 No.	125.5–150 %
		Number of Terms and Per cent of Total Falling in Rank Intervals											
Astronomy	17	0	0.0	5	29.6	7	41.2	1	5.9	2	11.8	2	11.8
Chemistry	9	0	0.0	0	0.0	2	22.2	0	0.0	4	44.4	3	33.3
Geology	15	2	13.3	2	13.3	3	20.0	3	20.0	4	26.7	1	6.7
Meteorology	9	0	0.0	2	22.2	2	22.2	4	44.4	1	11.1	0	0.0
Physics	40	2	5.0	6	15.0	9	22.5	7	17.5	9	22.5	7	17.5
Biology	60	20	33.3	11	18.3	4	6.7	7	11.7	7	11.7	11	18.3

Ranking was made according to the number of check marks each term received on the interest inventory.

rank intervals. If we then assign a score value of 6 to the highest interval and a score value of 1 to the lowest interval and then multiply that score value by the per cent of terms in that interval and then sum the scores, the sum of the scores for each science area would have relative significance when comparing the popularity or interest value of one area with respect to another. This operation was performed and the results are found in Table IV. It will be seen from this table that Biology with a value of 394.9 is highest on the scale, Astronomy with a value of 365.9 is second on the scale, Meteorology with a value of 355.2 is third on the scale, Geology with a value of 346.4 is fourth on the scale, Physics with a value of 310.0 is fifth on the scale and Chemistry with a value of 210.9 is last on the scale.

A further analysis and breakdown of the area of Biology which includes 60 terms and occupies the time of one half of the survey course should reveal the specific area of Biology which are of greatest interest value and those which are of least interest value. Such a breakdown can be accomplished if we designate the areas of Reproduction, Inheritance and descent, Response systems, Maintenance systems Disease and health, Basic Biology and Botany as areas to which we can assign each of the 60 terms.

TABLE IV

RELATIVE INTEREST VALUES OF SIX AREAS OF SCIENCE AS DETERMINED BY ANALYSIS OF DATA OBTAINED FROM THE RESPONSES OF 101 STUDENTS IN A SCIENCE SURVEY COURSE TO 150 SCIENCE TERMS

(f = % as found in Table V, and X = assigned score values for six rank intervals) *

Science Area	f	X	fX	Science Area	f	X	fX
Astronomy	29.6	5	148.0	Chemistry	22.2	4	88.8
II	41.2	4	164.8	VI	44.4	2	88.8
	5.9	3	17.7		33.3	1	33.3
	11.8	2	23.6				
	11.8	1	11.8				
					f = 99.9		fX = 210.9
	f = 100.3		fX = 365.9				
Meteorology	22.2	5	111.0	Geology	13.3	6	79.8
III	22.2	4	88.8	IV	13.3	5	66.5
	44.4	3	133.2		20.0	4	80.0
	11.1	2	22.2		20.0	3	60.0
					26.7	2	53.4
	f = 99.9		fX = 355.2		6.7	1	6.7
					f = 100.0		fX = 346.4
Physics	5.0	6	30.0	Biology	33.3	6	199.8
V	15.0	5	75.0	I	18.3	5	91.5
	22.5	4	90.0		6.7	4	26.8
	17.5	3	52.5		11.7	3	35.1
	22.5	2	45.0		11.7	2	23.4
	17.5	1	17.5		18.3	1	18.3
	f = 100.0		fX = 310.0		f = 100.0		fX = 394.9

* The inequalities of f are due to rounding off decimals in the hundredths to tenths.

The same procedure was used in assigning each of these area's values for comparison as was used in assigning the major area's values (Tables III and IV) with the results found in Table V. It will be seen from this table that these sub-subjects rate in the following order:

1. Reproduction
2. Response systems
3. Inheritance and descent
4. Disease and health
5. Maintenance systems
6. Basic Biology and Botany

TABLE V

RELATIVE INTEREST VALUES OF SIX AREAS OF BIOLOGY AS DETERMINED BY ANALYSIS OF DATA OBTAINED FROM THE RESPONSES OF 101 STUDENTS IN A SCIENCE SURVEY COURSE TO 60 TERMS FROM THE AREA OF BIOLOGY

Biology Area	f	X	fX	Biology Area	f	X	fX
Reproduction	89	6	534	Disease and	17	6	102
I	11	5	55	Health	66	5	330
				IV	17	2	34
	f = 100		fX = 589		f = 100		fX = 466
Inheritance	83	6	498	Basic Biology	6	5	30
and Descent	17	1	17	and Botany	10	4	40
III				VI	17	3	51
	f = 100		fX = 515		17	2	34
					50	1	50
					f = 100		fX = 205
Response	66	6	396	Maintenance	13	6	78
Systems	17	5	85	Systems	20	5	100
II	17	4	68	V	13	4	52
					20	3	60
	f = 100		fX = 549		27	2	54
					7	1	7
					f = 100		fX = 351

The results of this breakdown of Biological terms would seem to indicate major interest in Biology lies in those areas which directly pertain to ones self and ones behavior. These again one might describe as things essential to know for most successful living. Reproduction which is first in interest value to these college students includes the entire area of sex education. These responses are from young people who shall soon become marriage partners and gives evidence to the need for sex education. They are also for the most part people who have been sheltered from sex information. It has been the author's experience that during the part of the course which was primarily concerned with reproduction there was the highest class attendance and a larger number of questions asked of the instructor during and after class than when any other subject in the entire course was discussed. This would seem at least partially to validate the responses made to the words.

Second in interest value is the area of the response systems which includes the endocrine and nervous systems. These are particularly related to human behavior and an understanding of these allows for a better understanding of ones self.

It was considered necessary to determine whether a student's estimate of his interest in a particular area of science bore a relationship to his estimate of the value of those areas to him for his future. In order to make this determination the following question was submitted to a group of 42 students in the survey course.

Please rank the following subject areas of science in the order (A) of how interesting they are to you and (B) of how much value they are to you now and you think they will be in the future. There are six terms to be rated. Please assign values from 1 to 6 for both items A and B in the order of their interest and value. In your rating use all six numbers for each series. Use the number 1 to signify the area of greatest interest and of greatest value and 6 to signify least interest and least value and the other numbers for corresponding degrees of interest or value.

	A—Interest	B—Value
Astronomy	....	....
Biology	....	....
Chemistry	....	....

Geology	....	....
Meteorology	....	....
Physics	....	....

The results of this question are found in Table VI and Table VII. It will be seen from these results that Biology rated first in the group for interest, Astronomy second, Physics third, Meteorology fourth, Geology fifth, and Chemistry sixth. These agree in the first, second and last places with the results of the word check lists (see Table IV). The orders of Physics, Geology and Meteorology are reversed. In the results obtained from the estimate of the value of these areas it will be seen that the student does not necessarily feel that the interest in an area is related to the value of the area. On the value scale Biology rated first in the group, Physics rated second, Chemistry which rated lowest in interest rated third in value, Meteorology was rated fourth, Geology was rated fifth and Astronomy which was rated second in interest was rated last in value. This would indicate that the interest in an area may have some other motivation than the value of the area. If one were to base a course in science on interest factors alone he would be contradicting the student's own judgment on how valuable such a course would be to him. We might examine two such courses, one based on the results of the interest responses and one based on the results of the value responses. Let us agree that all six areas

TABLE VI

CUMULATIVE RESULTS OF THE RANKING OF 6 AREAS OF SCIENCE ACCORDING TO INTEREST VALUE AS EXPRESSED BY STUDENTS IN THE SURVEY COURSE

	Rank												
	6		5		4		3		2		1		
Science Area	N	RN	N	RN	N	RN	N	RN	N	RN	N	RN	Total RN
Astronomy	7	42	12	60	6	24	9	27	6	12	2	2	167
Biology	15	90	9	45	9	36	7	21	0	0	2	2	194
Chemistry	3	18	4	20	9	36	4	12	11	22	11	11	119
Geology	4	24	2	10	6	24	14	42	6	12	10	10	122
Meteorology	5	30	9	45	6	24	7	21	8	16	7	7	143
Physics	10	60	5	25	6	24	2	6	11	22	8	8	145
	44		41		42		43		42		40		

1. Rank 6 is highest interest and rank 1 is lowest.
2. R equals rank and N equals number.

TABLE VII

CUMULATIVE RESULTS OF THE RANKING OF 6 AREAS OF SCIENCE ACCORDING TO PRESENT AND FUTURE VALUE AS DETERMINED BY RESPONSES OF STUDENTS IN THE SURVEY COURSE

	Rank												
	6		5		4		3		2		1		
Science Area	N	RN	N	RN	N	RN	N	RN	N	RN	N	RN	Total RN
Astronomy	1	6	1	5	6	24	12	36	9	18	13	13	102
Biology	25	150	11	55	3	12	2	6	0	0	1	1	224
Chemistry	1	6	13	65	9	36	7	21	8	16	4	4	148
Geology	1	6	2	10	8	32	10	30	9	18	12	12	108
Meteorology	3	18	6	30	9	36	9	27	10	20	5	5	136
Physics	11	66	10	50	8	32	1	3	6	12	6	6	169
	42		43		43		41		42		41		

1. Rank 6 is greatest value and rank 1 is least value.

are to be included in this course in science. Based upon the results shown in Table VI which ranks the areas of science in accord with the expressed interest value of these areas we would construct a course with the proportional distribution of material as shown in Table VIII.

allocating time and that the value of the subject matter to the student for present and future use should be an acceptable basis upon which to allocate time we might then agree with the results of basing our time allocation upon student estimate of the value of each area, as shown in Table IX.

TABLE VIII

THE PROPORTIONATE DISTRIBUTION OF SUBJECT MATTER WHICH WOULD BE GIVEN IN A SCIENCE SURVEY COURSE (ALLOWING 120 LECTURE HOURS FOR THE COURSE) BASED UPON A GROUP OF STUDENTS' ESTIMATES OF THE INTEREST VALUE OF EACH AREA (See Table VI)

Subject	No. of Hrs. Based upon R × N of Table VI	Per cent of Total R × N	R × N*
Biology	26	22	194
Astronomy	23	19	167
Physics	19	16	145
Meteorology	19	16	143
Geology	17	14	122
Chemistry	16	13	119

* R × N is based upon results shown in Table VI.

These figures seem completely out of line with established practice in science courses primarily designed for general education.[9] Apparently educators who have established these courses would disagree that the time allocated to the various subjects should correspond to the values obtained from this expression of student interest. If we agree, however, that interest alone should not be used as the criteria for

[9] N. S. Washton, "A Survey of Science Courses for General Education in Colleges," *Association of American Colleges Bulletin*, 34:285–94, October, 1948.

The group which gave these results were a group of students going to an urban college within a large industrial area. They were primarily non-science majors. The results obtained from this group are probably very different from the results which might be obtained from a group of students in an agricultural area. We could not assume, therefore, that students from other groups would give similar results. It is interesting, however, that the allocations of time based upon area value is in fair agreement with current practice in the allocation

TABLE IX

THE PROPORTIONATE DISTRIBUTION OF SUBJECT MATTER WHICH WOULD BE GIVEN IN A SCIENCE SURVEY COURSE (ALLOWING 120 LECTURE HOURS FOR THE COURSE) BASED UPON A GROUP OF STUDENTS' ESTIMATES OF THE PRESENT AND FUTURE VALUE OF EACH AREA TO THEM (See Table VII)

Subject	No. of Hrs. Based upon R × N of Table VII	Per cent of Total R × N	R × N*
Biology	30	25	224
Physics	23	19	169
Chemistry	21	17	148
Meteorology	18	15	136
Geology	14	12	108
Astronomy	14	12	102

* R × N is based upon results shown in Table VII.

of subject time in such courses as they are being given in American colleges.[10]

In this paper we have described a method for estimating the science interests of a group of college students. On the basis of these expressed interests we have shown how the time devoted to a science survey course may be broken up into units allowing each unit a time span in accordance with these interests. It has been pointed out, however, that even the students would disagree with this plan since their estimate of the present and future value of a particular science subject does not necessarily coincide with thier interests. The pattern that the science survey course is taking in many colleges throughout the country seems to be following the direction suggested in this paper.

[10] Washton, N. S., *op. cit.*

SAMUEL CHRISTIAN SCHMUCKER *

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DR. SAMUEL C. SCHMUCKER'S grandfather, from whom he was named, founded Gettysburg College and was head of the theological seminary there. His father was also a clergyman in charge of the Lutheran Congregation in Reading. His mother worked so hard helping the congregation earn his father's salary that she broke down completely. Today she would be sent to a sanitarium for a rest but then the family physician said "go walking day-by-day."

Every pleasant afternoon after school and all day Saturday the parents came for Samuel, (born in 1860) age eight, and his brother who was two years younger. There were no street cars but the canal boats loaded with coal never refused them a ride up or down to the next lock or two which would be the starting point for walks. For years they roamed the banks of the Schuylkill and the beautiful Pennsylvania hills. The father had learned enough botany from an old fashioned text, which dated back earlier than Gray, to identify the flowers. The key was of the Linnaean style where the plants were grouped according to the number of stamens and pistils. In this way he acquired an early knowledge of the trees and flowers. Strange to relate, little attention was given to the birds. It is to be noted that the trips were for fun and not for study.

The Schmucker family discovered a country tavern in the Blue Mountains where they could board as cheaply as at home. They went there summers until Samuel went to college. It was here that he discovered a peculiar rock field and he wrote to Le Conte to find out if it was a glacial phenomenon. Le Conte suggested that it was a Felsen Meer (Sea of Rocks). This was Schmucker's first correspondence with a man of note.

At college young Schmucker was laboratory assistant to Dr. Edgar Fahs Smith who had all the sciences at Muhlenberg College, Allentown, Pennsylvania. Dr. Smith was chiefly a chemist and made a chemist of his laboratory helper who was later to receive a Ph.D. in chemistry and minerology (1891) at the University of Pennsylvania under the same Dr. Smith. This made Dr. Schmucker science minded. Dr. Schmucker obtained his A.M. from Muhlenberg in 1882.

After receiving his degree in chemistry he realized that biology could throw light on the things he loved and on which up to this time, he had spent his spare time. He was now located at West Chester Normal (1895–1923) and was near enough to the University of Pennsylvania to run down on

* Based largely on notes from an interview with Dr. Samuel Schmucker, a noted interpreter of science and known by a number of older members of N.A.R.S.T.

Saturdays and take work in biology. Professor MacFarlane in botany made a distinct impression on Dr. Schmucker. The botany professor was the first man in a position of importance who thought that Dr. Schmucker was doing a worth while job in giving popular nature lectures at institutes. Others said—"get back in the laboratory and do something worth while." Fortunately for the service of teachers in particular and for the benefit of mankind in general, Dr. Schmucker decided that there were too few interpreters of science who were not either too sentimental or too technical. He envisioned the need and decided to give his life to the interpretation of science rather than to the investigation of science.

He next studied zoology with Edwin Grant Conklin who came to the University about this time. Professor Conklin was the next big man who thought that nature study was worth while work. The attitude of these two scientists gave him confidence. His associates also paid him the compliment of making him president of the Biology Club. Some of the members of the club got together and had a caterer serve a little lunch for those who were to stay over for the evening meeting. Two of these were Cope and Conklin. Cope was America's greatest Lamarckian and Conklin was a disciple of Weissman. Night after night these intellectual giants debated the burning question as to whether acquired characters could be inherited. Dr. Schmucker counts this as the best science lesson of his life. He learned that two men could differ absolutely in attitude and yet be courteous and the warmest of friends. This taught Dr. Schmucker that he should state his own position clearly and let time make the decision. This example may have been the reason for his always having avoided a scientific quarrel.

One summer Professor John Sterling Kingsley of Tufts College (1892) headed the Summer School of Biology at the University of Pennsylvania. Shortly before that Kingsley had written "The Naturalist's Assistant", a Hand-Book for the collector and student. (S. E. Cassino, Boston, 1882) which dealt with pinning insects, breeding larvae, and the use of the microscope. Perhaps it could not even be considered a forerunner of nature study but is interesting because of the following statement (page 105): "There is but one way in which zoology should be taught—*directly from the specimen.* There are in the United States some 370 institutions which rejoice in the name of College or University, but not ten per cent afford their students the slightest facilities for practical work". Dr. Kingsley hopes that "specimens will replace the text book instruction" but he evidently did not surmise that he had a student who would lead students to living material in the field instead of pinned specimens on the table. One time Dr. Kingsley gave the student Schmucker a June bug to draw. Later he said "why so fuzzy?" This occasion was the stopping of fuzzy drawings. Schmucker knew that the professor wanted *structure.* Among the students that summer he met Mrs. Lucy Langdon Williams Wilson, Cope, and Robinson co-author of Gray's Botanical Key.

Perhaps the next big formative influence in his professional life was the series of lectures which he gave for eight years on Fridays and Saturdays for Dr. Leipziger of the New York City Schools. Dr. Leipziger was the head of the Bureau of Free Lectures for the Public Schools. The most successful year for his program included over 4,000 public lectures. Dr. Schmucker, probably on account of his thorough preparation in science, was often assigned to the American Museum of Natural History. Dr. W. K. Gregory watched the young lecturer very closely which resulted in a warm friendship. He also lectured frequently at the Cooper Union which always had a stimulating audience, socialistic in attitude, and eager with questions. Dr. Schmucker found this to be a wonderful experience.

About this time he became interested in the evolution of man. He used the collections of the American Museum extensively. This soon resulted in the iridescent hope that he might have a set of specimens that would run from an eolith to the neolithic. He wrote to Dr. Clark Wissler to see if it would be possible to purchase from their duplicate specimens, characteristic members of each group. Dr. Wissler got Dr. Nelson to pick out a series of 12–15 specimens and told Dr. Schmucker that he could purchase as many of these as he wished. The series ran back for hundreds of thousands of years and Dr. Schmucker's heart went out to them. He made up his mind although a "poor teacher with a family" he would pay one hundred dollars if necessary. He asked Dr. Nelson—"what is the price for these?" Dr. Nelson said "which do you want?" Dr. Schmucker swallowed and said "what must I pay for the complete series?" Dr. Nelson replied "ten dollars". Dr. Schmucker then realized that Dr. Nelson didn't dare to encourage people to come and buy and he didn't dare to give them away. Again he experienced the cooperative attitude of scientists and this gave him heart. The collection is one of his prize possessions of today. It led to the writing and publication of "Man's Life on Earth" (1925).

One time when lecturing in Northern New Jersey a stranger approached and said "Do you know my counsin Mathews of the American Museum?" Dr. Schmucker admitted that he was sorry but did not except by reputation. He then added "Do you have any influence with Mathews?" It developed that the Museum had a rare specimen—the skin of the extinct hairy elephant with eight inch hairs and fine underhair. Dr. Schmucker said that he would like just one hair. He heard nothing from the episode for a month when there came via mail a glass tube with about a dozen hairs and a little bit of under-pelage. This also gave him courage as a young man.

In the summer of 1893 Dr. Schmucker began to go to the New York Chautauqua. Anna Botsford Comstock and Uncle John Spencer were there carrying on Nature work for the Agricultural Department of the State. Dr. Schmucker lectured on the "Meaning of a Flower" and these two came and stood at the top of the open air auditorium. After it was over Mrs. Comstock came and said "Dr. Schmucker, that was splendid. You know what to leave out." They later came to know each other well.

Dr. Schmucker visited her class one day, while she kept on teaching, she picked up a notebook and passed it over. A country boy had made pictures and notes in what was a fine, discriminating notebook. It was made by Vaughn MacCaughey before he came to Cornell. Later MacCaughey went to do Nature work in the University of Hawaii. The young man was in the class and Dr. Schmucker met him. Vaughan was afterwards his assistant for 2–3 summers at Chautauqua where Dr. Schmucker headed the work in science (1906–1928).

Since 1907 Dr. Schmucker has been Dean of the Faculty and Professor of Zoology at the Wagner Free Institute of Science (Incorporated 1855). Wagner was the Peter Cooper of Philadelphia. It was in 1907 that Samuel C. Schmucker's "The Study of Nature" appeared. Dr. Schmucker feels that nature study has given him great happiness at no cost. Although Dr. Schmucker lives in West Chester he is an important part of the story of nature study in Philadelphia. He not only obtained his academic training there but has inspired many leaders in the philosophy of outdoor understanding. He has passed his three score and ten in years but has the spirit of youth and through the Wagner Institute is giving freely of his great personality and experience. He is a nature leader of the first magnitude.

Publications by Dr. Schmucker included: *The Study of Nature* published by the Macmillan Company, 1907; *Man's Life On Earth* by J. B. Lippincott Company, 1925; *Heredity and Parenthood*—3rd revision—by The Macmillan Company, 1929.

MRS. LUCY LANGDON WILLIAMS WILSON *

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LUCY LANGDON WILLIAMS was born in St. Albans, Vermont, on August 18, 1864. She first attended private schools taught by "gentlewomen.' When asked what reader she should start with, she looked up and saw a book with III on it so said the "Third Reader." She had never seen a reader. Her mother read her a story from it about "Good Morning Merry Sunshine," and the daughter "read it right back." Both the teacher and the mother thought that she was *reading,* but she wasn't. Such teachers naturally did not interest Lucy Williams.

As a little girl she often lived with her grandmother in Rutland. Her grandmother had an oldfashioned English garden hedged in with box and with a background of pines. The grass was planted with narcissus and daffodils. The grandchild was given a little stretch of her own. The story also comes down that her father took her out in a baby carriage which he filled with flowers and leaves. Her interest in nature was aroused in the green mountain country so early and naturally in fact that she was probably unconscious that it was going on. She was surrounded by nature and play brought her to nature and nature to her.

She lived in Vermont until thirteen, coming to Philadelphia in April, 1879. She had attended Castleton Academy and Normal and upon coming to the big city entered the second year of the High and Normal School. She had studied geometry but not arithmetic, but she always "skipped into things." In high school she was given "How Plants Grow" by Gray and was taught botany by the elocution teacher. The teacher was ignorant of botany, a calamity which present day experience too often parallel. Someone brought in a hepatica and the teacher called it "liverwort." Miss Williams was interested enough to read about it in Gray and told her discovery that liverworts do not blossom. The city teacher would not believe the "Wild Animal from Vermont." Miss Williams wrote Asa Gray. When she showed the reply of this kindly old gentleman, the teacher would not acknowledge the mistake but considered it just rebutting.

Then came a teacher of methods from Oswego Normal—Mrs. Clara Burr, who was somewhat familiar with nature study. Mrs. Burr came for the magnificent salary of $1,500, and the other teachers were getting $800. There was nothing gay about Mrs. Burr and the salary situation developed a jealousy amongst the other teachers. Mrs. Burr was unhappy. Mrs. Burr became interested in the girl who knew nature. Lucy Williams obtained a great deal of help and a feeling for nature from Mrs. Burr although her main aim was object teaching and methods. Through Mrs. Burr the young student learned about Doctor Sheldon and Steele's "Fourteen Weeks."

Miss Williams became Mrs. Wilson (1893). Dr. William Powell Wilson as a student was an assistant to Agassiz and in about 1879 was an instructor under Goodale. He also studied under Sach in Germany. He was Director of the School of Biology and Professor of Physiological Botany at the University of Pennsylvania. Whether she realized it or not—biology was the guiding star of her life.

It may have been heredity, it may have been environment, but probably it was both that enabled the son, David Hawxhurst, to graduate from Harvard with Cum Laude in 1919. Later he received a doctorate and was Research Fellow for two years. The

* Based largely on notes from an interview many years ago with Dr. Wilson, noted Philadelphia nature study leader and educator.

parents not only believed in the pedagogical principle of letting youth follow his own lead, but put it into practice with their son. When he was offered money or a chemical laboratory, he chose the latter and through his own efforts was enabled to pass the Harvard entrance examination in chemistry. For the benefit of the son, the parents made their home in the country for twelve years.

Probably every successful naturalist has had an outstanding teacher in the past. Mrs. Wilson got more inspiration from Charles S. Dolley, Professor of Biology at the University of Pennsylvania, than from any other individual. Dolley was a protege of Joseph Leidy. Leidy passed out of the picture too early for Mrs. Wilson to receive much direct influence from his work. She received her Ph.D. from the University of Pennsylvania in 1897.

It was not long before Dr. Wilson went farther afield. At the Agassiz Memorial meeting in Cambridge she met many pupils of Agassiz—Edward Morse, David Starr Jordan, Burt Wilder and Scudder, the butterfly man. She heard William James say that the best lesson in psychology that he ever had was that memorable lesson on the fish with Agassiz. Similarly that same lesson was Wilder's best brain and Scudder's best butterfly lesson. At Cornell she used John Henry Comstock's *Insect Book,* sat at the feet of Anna Botsford Comstock and was stimulated by Liberty Hyde Bailey. Her spark of nature interest was fanned into a flame. How could it be otherwise?

Doctor Lucy Wilson's reputation as a nature teacher was not local. She went on lecture tours through cultural New England. She lectured to a teacher's group at A. C. Boyden's Bridgewater Normal. When she arrived at the Rhode Island Normal School, Mary Dickinson and her class were out on a field trip. She noticed that they came back with enthusiasm. Because of this Mrs. Wilson returned to the Philadelphia Normal School and started bird trips at once, although the class there numbered 400 instead of 40. Mrs. Wilson defines *originality as intelligent assimilation.* She was quick to see and quick to put good things into practice. Mrs. Wilson taught herself first, but she did not stop there. She then taught others. She had four assistants. They met the girls at 6 A.M. and got back at 11 A.M. The class was so drowsy that the other teachers became profane. Such long hours must have been a strain on the nature teacher, but a bigger one on the rest of the faculty. Mrs. Wilson went on the theory that if the girls didn't like the birds something was the matter with them. She had only one such case and on investigation found that the student was a moron in all her other classes.

Another idea was received on this visit to the Rhode Island Normal. She visited the class of Fred Gowing, who was principal. He gave a demonstration lesson in the Observation School and then had a discussion meeting with the student teachers. Mrs. Wilson adopted Fred Gowing's hint and took her girls into the grades and demonstrated and discussed with absolute frankness. She then let the girls teach and they criticised each other.

Mrs. Wilson established the first botanical laboratory in Philadelphia at the Normal in 1893. Two laboratories seventy feet long were made by removing walls. The next year she opened a zoology laboratory and in 1895 started nature study in the grades. She taught the children herself, beginning in the first grade and took these children on up through the grades.

Mrs. Wilson taught Darwinism and evolution from the very beginning (1893) until she resigned in 1916. This was remarkable for a conservative city like Philadelphia, but these were the days of fairly intelligent students. She had the foresight to give out a syllabus each time. If anyone wrinkled his eyebrows, she would produce the syllabus and say, "Ask any question you want" *and no one said "boo."*

Out of this wealth of experience was produced her "Nature Study in Elementary Schools," a Manual for Teachers (Macmil-

lan, 1897). In the preface, that notable nature study champion, Francis W. Parker, wrote that it was "planned chiefly to meet the needs of the ordinary grade teacher in the public schools of a city." Mrs. Wilson wrote that "last year I made not less than eighty short excursions with children (7–14)." Once she withdrew in favor of a circus parade which was not orthodox pedagogy in those days. Her book gives facts for the busy teacher, is rich in suggestion for the teacher without training, is abundantly illustrated, has a list of myths, legends, poems and stories, suggests related works and has seasonal arrangement. Each month, topics are suggested under weather, plants, and animals. That the book is prophetic of integrated units of work and visual education is suggestive of the progressiveness of the author. That it was not adopted in Philadelphia showed nearsightedness on the part of the powers on the throne.

Mrs. Wilson wrote one of the earliest sets of nature readers. The first reader appeared in 1899 and is the basis for enriching experiences. On being asked if she was not the "Mother of Nature Study in Philadelphia," she came back like a flash, "Yes, but it was still-born."

In these days there was no nature study in the Philadelphia course of study and physiology was nothing but pure anatomy. The school principals had had no nature study and the newer graduates were not strong enough to meet the situation. The young teachers were leaving the training school with a great deal of enthusiasm. Unfortunately, the appointments in those days were political. Out of the 400 students many of the most promising would not get positions. Most of the students who started with the right spirit were not able to carry on nature study in opposition to the existing forces. Mrs. Wilson criticizes herself for remaining contented in her own work. She really didn't understand the situation until years afterward. The amazing thing is that no local superintendents had seen or knew about the nature study work at the Philadelphia Normal School. Other superintendents from other places knew about it and Sir Arthur Thompson took Philadelphia nature work all over England and Scotland in an exhibition. Philadelphia remained a sleeping lioness. The English Nature Study Society gave her their medal.

In Mrs. Wilson's book appeared, "Mrs. Lucy Langdon Williams Wilson, Head of the Biological Laboratories in the Philadelphia Normal School for Girls, and in charge of the Nature Work in the School of Observations in Practice connected with the Normal School." The President of the Board of Education once asked her husband where Mrs. Wilson got her title, and he said "She probably took it on herself."

When the superintendent named a committee to write a new course of study for geography Mrs. Wilson was appointed a member. She does not recall how she became chairman, but it may have been by the same way she obtained her title at the Normal School. When the course was presented, it inspired the superintendent with horror. Perhaps he "suspicioned" evolution. As a result, he added several school principals to the committee with instructions to oppose the methods. Later he put on a new group, but each time the committee became sold on the idea. The course was pigeon-holed for several years. As a last resort, the superintendent resolved the course into statements of bare facts with the time to be used and formal geography prevailed.

In the meantime, Mrs. Wilson went to South Philadelphia to organize the high school for girls (1915–1934). Her most important contribution to that high school was the translation of the nature study ideal into other subjects. Soon the laboratory methods, excursions and the like became an integral part of English, Mathematics, the Social studies and other secondary subjects. Most of the science laboratories of the Normal School were subsequently destroyed. The room partitions were restored

and the teachers were given other subjects. The year that Mrs. Wilson retired from the South Philadelphia High School she was recipient of the $10,000 Bok Award for service rendered for the good of Philadelphia. From 1934–36 she was lecturer at Temple University.

Dr. Adeline Schively succeeded Mrs. Wilson as head of the Biological Department. After her resignation, nature study was represented by one teacher, still teaching nature study in the Practice School. In 1926 Doctor Edward E. Wildman was made director of Science Education in the Philadelphia Public Schools. His efforts have brought about a better approach in the high schools. The work in the elementary schools is unfortunately limited to the first three grades. Individual teachers have been able to do things, but in proportion there are probably no more elementary teachers teaching nature study today than there were thirty years ago. It has been a gallant struggle. It should count for more.

Publications included: *History Reader for Elementary Grades* published by the Macmillan Company, 1897; Set of Nature Readers 1899; *Educating for Responsibility* (co-author), the Macmillan Company, 1926; *New Schools of New Russia,* the Vanguard Press, 1928.

THE USE OF TEXTBOOK ANALYSIS IN DETERMINING COURSE CONTENT FOR PHYSICAL SCIENCE GENERAL EDUCATION COURSES

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WHAT the contents of any course should be should depend upon the objectives set up for the course.[1] One way of looking at objectives is the two component method employed by Tyler, viz., to consider an objective as made up of a behavior aspect and a content aspect.[2] Once we have adopted the generally accepted concept that the purpose of education is to change the behavior of individuals, we will then find it advantageous to express any objective in terms of a type of behavior (one component) in a specified content area (second component).

For example, "understanding of certain principles of science" might be a typical objective in a physical science general education course. (The reason for selecting this example will be evident later in the paper.) In this objective, "understanding" is the behavior aspect and "certain principles of science" is the content aspect. Although as stated, this objective meets our assumption with regards to the purpose of education and the requirements for formulating an objective, to be of any functional service to the teacher the terms "understanding" and "certain principles" will have to be further defined. For example, understanding might be defined as the ability to *recall* the principles, *state* them in different words from those used in a text, *apply* them in new and different situations, etc. And similarly, what these certain principles are must also be enumerated.

The word "certain" was used advisably since obviously not all of these principles of science can be included in a single course. Without elaborating numerous reasons why a selection must be made, it will suffice to mention only one factor—the time element. It is the selection of these principles which is the concern of this study.

[1] The writer is indebted to Mrs. William Burleson and Mr. Roy Marlow, Chico, California, for their assistance in this investigation.

[2] Ralph W. Tyler, *Basic Principles of Curriculum and Instruction.* University of Chicago Press, Chicago, 1950.

Because the above mentioned objective is a fairly common one in physical science general education classes and because a part of the objective deals with *certain* principles, I suppose the energy expended in the past few years to determine the "most important" principles (and thus include them) is justifiable. Assuming this, the question then reduces to: Can we objectively determine what scientific principles, which an educated non-science citizen should know about the physical world, are of higher and lesser importance?

Many studies in the past few years have been concerned with textbook analysis for determining what principles are most important. It is this approach which is to be criticized, and for several reasons.

1. One criticism which can be leveled against the textbook method of analysis is that it is too limited in its outlook and in its scope. It does not take into consideration such valuable sources for determining course content as educated non-scientists, general education experts, the interest and needs of students, etc. Although in actual practice many texts are analyzed, the basic assumption here is that the single source is adequate for determining the content aspect of this objective. This method is dangerous in that while textbooks are being analyzed, other objectives, such as skills, knowledges, attitudes, and the like, may be ignored.

2. A second criticism is that underlying this method of textbook analysis is the basic assumption that all authors include only those principles in their texts which they think to be most important for a student to know. This may or may not be a valid assumption. Certainly it is questionable. If this were the major purpose of all authors, for what reason are there so many texts on the market for physical science general education courses?

3. Even if we were to agree that this method of textbook analysis is restricted in its application, a third criticism arises when we investigate the validity of the method itself. Data for testing the validity of this method was made available by the study conducted by W. W. E. Blanchet.[3] Blanchet's work consists, in part, of an analysis of 272 fundamental principles of physical science.

In one case he had nine science experts rank these 272 principles on a five point scale of importance, and the average rating calculated and assigned to each principle. In the second instance he examined 10 standard textbooks in the field and tabulated the number of books which included a discussion of each of the 272 principles. Thus he obtained a frequency scale ranging from 0 to 10. We thus have two groups of experts, authors, and men of science, who might be compared. One might question the permissibility of correlating these two groups for two reasons. One involves the scales employed. Whether the distance between most important (counted as 5) and some importance (counted as 3) is the same as the distance between some importance and little or no importance (counted as 1) is undeterminable. A similar objection could be raised with regards to the frequency count obtained from the texts. In both cases we are assuming a linear scale with equal intervals. A second reason is that the assumption that the authors included those principles they thought important, leaving out those they considered least important, may be true only to a degree. The authors usually have knowledge of the physical world, that is, understanding certain principles of physical science, as an objective of their book. However, they also have other goals, e.g., understanding the scientific method, that might be used as a basis for selection and omission of principles. Nevertheless, to the extent that knowledge of the physical world is their pri-

[3] W. W. E. Blanchet, "A Basis for the Selection of Course Content for Survey Courses in the Natural Sciences," unpublished Doctor's Dissertation, University of Michigan, 1947. Units of Dr. Blanchet's dissertation were published in *Science Education*, 32:24–32, February, 1948, and 32:88–93, March, 1948. The data used in this study is taken directly from his dissertation, and in the main, is not found in these two articles.

mary objective, this will be their chief basis for selection. Thus to correlate the two groups and find their degree of agreement is probably as justifiable in this case as in many others when correlation technique is used.

The correlation coefficient found was 0.465. In interpreting this coefficient, we note that it is definitely positive, but, when one considers both groups fall in the same classification, the agreement is remarkably small. That all should agree, which they did on some individual principles, is not to be expected, but, *a priori*, one might have hypothesized a much higher coefficient, say, around 0.80.

4. A further criticism of the textbook method results from a second investigation made by this author. An attempt was made to use the educated but non-scientifically trained public as a source for determining the most important principles. The original plan called for a sample to be taken from a wide variety of college graduates, e.g., lawyers, business men, housewives, etc. However, the faculty of Chico State College and of the College Elementary School, Chico, California, were sampled first in order to determine the weaknesses in the questionnaire method to be employed and as a check to see how their replies would compare with the two sources discussed above. It should be kept in mind that even though they are all teachers, the persons sampled represent a wide variety of backgrounds. Thus it might be inferred that the sample is somewhat representative of a wider population.

For the non-scientist it was found that the principles by themselves are often abstract and transfer a minimum of meaning. To remedy this, a practical illustration of each was added along with a principle, and, rather than burden the faculty member with the entire set of 272 principles, twenty were selected at random. The selected twenty were put into a questionnaire with instructions to apply a five-point scale of importance (to them as educated non-scientists) when judging each principle. The average rating for each principle was then determined from the first 39 replies.

A follow-up by personal interview with those who replied brought out minor points of vagueness and ambiquity in the schedule, but more important, revealed two weaknesses which might vitiate any results from such an approach. Firstly, the persons interviewed were honest enough to admit that in some instances their evaluation of a particular principle was arrived at more by the significance of the illustration than by the principle itself. This was taken into consideration in preparing the illustrations, and the attempt was made to choose those with which all would be familiar. However, it is conceivable that a different illustration of a principle may have affected the importance attached to it by the persons questioned. This point could be checked by a second questionnaire at a later date which would contain the same principles, but with different examples.

The second point brought out is more disturbing than the above mentioned in that some admitted attaching a high importance to those principles with which they were familiar, and a low rating to those with which they were not. Although the instructions on the schedule asked them indirectly to be careful of such an event, it seems difficult to eliminate or control the personal element to the extent its variance would not influence their replies.

Realizing these weaknesses, and probably others, a correlation was run between the average of their evaluations and the science experts' and between the average of their evaluations and the author experts'. The results were 0.70 and 0.13, respectively. The correlation between science experts and author experts for these 20 principles was 0.11. In that it is valid to infer anything from these results we see a good agreement between the science experts and the non-science faculty, and practically no more than chance agreement between the faculty and author experts, or between the science

experts and the author experts. That is, we see science experts and educated non-scientists agreeing with each other, but not with the authors. Again, the validity of the textbook method of analysis is seriously questioned.

In addition to the above investigation, using students as a source for determining which principles are most important was undertaken. In the first meeting of a physical science course about 100 students were given a set of instructions which asked them to write out all questions about science for which they would like to know answers. They were put as much at ease as possible. They did not have to sign their names. They could write as many questions as they desired in the one-half hour allowed, that is, conditions were arranged so as to obtain genuine and sincere inquiries. The assumption was that their questions would express their interests.

About 1,000 questions were collected. The plan was to analyze each question and determine which of the fundamental principles would have to be understood before a satisfactory answer to the question could be given. Then by a frequency tabulation of the number of times a principle was needed to answer the question, its importance could be ascertained. It was felt that this indirect approach would be more valid than simply having them rate the 272 principles on some arbitrary scale.

In addition to the tremendous amount of material and the time demanded for a thorough analysis, several complications arose which seemed to the writer would invalidate any inferences drawn from the analysis. Firstly, although the number of questions seemed like a sufficient amount, when the pure factual type question, e.g., "How many miles to the nearest star?" etc., when the ambiquous questions, and when the questions that are outside the field of a physical science course were discarded, the sample was greatly reduced.

Secondly, it appeared that many questions were concerned with topics given recent attention in the local community. At the time these were collected, considerable discussion revolved around the effect of the atom bomb on the weather. This immediately raised the problem of how permanent their interests were and of what real value they might be in determining course content in the proposed manner. A check was made about four months later by examining questions collected at Herzl Junior College in Chicago. Beginning students in physical science were given identical instructions as the Chico students. Their questions showed interest in television, prevalent in Chicago but non-existent in Chico, and in jet power. Thus, even if this approach has any merits, it appears as if it is limited both by geographical area and by time.

Thirdly, analysis of questions for underlying principles is a rather subjective technique. To ascertain what principles must be understood before a "satisfactory" answer can be given raises a semantic problem. What criteria can be used which will operationally define what is meant by "satisfactory?" How much has to be known before a question is "satisfactorily" answered? For example, to some this means always going back to such a principle as the conservation of mass-energy; to others, going to such depths is not necessary. Or, for some questions perhaps only the main underlying principle need be understood whereas for another question many principles, in addition to the immediately underlying ones, must be understood. At any rate, the degree of subjectivity was so great that this attempt was abandoned.

CONCLUSION

Although the results of this investigation were primarily negative, there is no justification for the conclusion that the order of importance of principles of science which an educated non-science citizen should know cannot be objectively ascertained. However, it is borne out by the evidence

that the methods of textbook analysis, questionnaire, and student opinion are not valid procedures—especially the first mentioned.

It is the opinion of the author that the selection of course content, and specifically principles of science, would best be undertaken and carried out by first operationally defining what student behaviors are desired (and not limited to understandings and knowledges) as a result of this type of a general education course and *then* choosing the content material which will best develop these behaviors. It is hypothesized that such a procedure would result in the inclusion of the majority of those most important principles—provided they are ever objectively and validly ascertained and assuming it is worthwhile to attempt such a task.

SOME INTERESTING ETYMOLOGICAL DERIVATIONS OF CHEMICAL TERMINOLOGY

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ACACIA

The gum, acacia, comes from the acacia tree. The name is derived from the Greek "akakia," referring to a thorny bush found in Egypt. This latter name is probably based upon the Greek "aké," meaning "a point."

ACID

The word is based upon the "sharpness" which is generally associated with acidic substances. It is derived from the Latin "acus," meaning "needle" and through that to the Latin "acer" (sharp). This is the same etymological basis for similar names and words like "acrid," "acridine," "acrolein," etc.

ADENINE

This is an alkaloid of the purine series. It is a cleavage product of nucleic acids found in the pancreas and other animal glands. The name is directly derived from the Greek "aden," meaning "gland."

ADIPIC ACID

This dicarboxylic acid so prominently used now in the manufacture of NYLON is produced by the oxidation of cyclohexanol. Originally, however, it was obtained by the oxidation of fat. The name is derived from the Latin word for "fat," which is "adipis."

ADRENALIN

This is the hormone secreted by the adrenal glands which are located directly above the kidneys in the body. The name is derived from the Latin "ad," meaning "near" and "renes" meaning "kidney."

ALBUMIN

This is the name given to a class of proteins found in blood serum, milk, eggs, etc. The albumins were formally thought to be different manifestations of a single substance "albumen" which was thought to exist nearly pure in the *white* of egg. The name is derived from this reference and the Latin "albus" meaning "white."

ALCOHOL

The word is based upon the Arabic "al-kohl," which was the name for a fine black powder used as a cosmetic for the eyelids. During the course of years, the name was applied to any fine powder. In time it came to refer to the "fineness" rather than to the "powder." Later it was applied to anything pure or "distilled" and ultimately to the product of distillation of wine; the alcohol we know today. It is possible that the Arabic word is also the basis for our word "coal."

ALLYL
The name for this radical is based upon the fact that its compounds (allyl isothiocyanate) are found in oils of garlic and mustard. It is derived from the Latin "allium" (garlic).

ALUM
This is derived from the Latin "alumen" which was the name for the various mixtures of salts used in dyeing processes. The main ingredient of these mixtures was the common alum of the present day, potassium aluminum sulfate. The name for the element, aluminum, is, of course, derived from the same source.

AMMONIA
In Egypt and Libya, the God, Jupiter, was worshipped as Ammon. The camel dung which was cleaned from the temple of Ammon, upon leaching, produced a salt-like substance. The Latinized name of this compound became "salammoniac"—the "salt of Ammon"—ammonium chloride. The name for ammonia is then derived from the fact that the compound is readily produced from sal ammoniac upon treatment with base.

ANDROGEN
This general name for male hormones is derived from the Greek "andros" (man) and "genes" (to make).

ANILINE
The Sanskrit word for "dark blue" is "nīla." From the color of the dyestuff obtained from the indigo plant, the Arabs called the plant "al-nīl." The name aniline was given to the compound when, in 1826, Unverdorben first prepared it by the destructive distillation of indigo.

ANISOLE
This compound (methyl phenyl ether) takes its name from the Greek "anisos" meaning "unequal" in reference to the fact that the two groups joined by the ether linkage are dissimilar.

ANTICHLOR
This is a common name for sodium thiosulfate. The name is based upon the fact that the material is useful for reacting with and removing excess chlorine which has been used as a bleach in, for instance, paper manufacture.

AQUA FORTIS
This name is derived from the Latin meaning "strong water." This is in reference to the fact that nitric acid will react with and dissolve copper and similar unreactive metals. The name AQUA REGIA ("royal water") also Latin, is based upon the ability of this mixture to react with and dissolve the "noble" metals, particularly gold.

ATROPINE
This alkaloid takes its name from the behavior of the plant (Atropa Belladonna) from which it is obtained. A common name for the plant is "nightshade" since it, unlike most other plants, does not seek the sun or "turn to the sun." The Greek "a-trope" means "not turning."

BARYTES
The mineral, barytes, is one of the heaviest known, having a specific gravity of 4.3 to 4.6. The name is derived from the Greek "barys" meaning "heavy."

BLENDE
This is a general name for several minerals, e.g. zinc blende, most of which are lustrous sulfides. The bright and shiny appearance is responsible for the name, which comes from the German "blinden" meaning "to blind."

BORAX
The Modern English name for this mineral is derived from the old Persian name "būrah." This became, in Arabic "bawrag" or "būraq" and "borax" in French.

BORNEOL
The name means, literally, "oil of Borneo." It is closely related to cam-

phor and is obtainable from plants which grow in Borneo, Sumatra and the Malay States.

BRIMSTONE
This old name for sulfur comes from the Anglo-Saxon verb "baernen" (to burn). Sulfur, in Medieval English was called "bernston" (burning stone) and changed to "bremston" and later "brimston."

BUTANE
The saturated hydrocarbon with four carbon atoms as are also present in butyric acid. This acid is found free in rancid butter, from which it takes its name. The Greek for "butter" is "boutyron," which became "butyrum" in Latin.

CALICHE
This name refers generally to crude sodium nitrate of the Chilean deposits and also in crusts of calcium carbonate which form on stony soil in arid regions. It is derived from the Spanish "caliche" meaning "a pebble in a brick."

CALOMEL
There is some doubt as to the exact etymology of this word. It comes from the Greek "Kalos" meaning "beautiful" and from either "melas" (black) or "meli" (sweet). The former may refer to the black produced upon the reaction of mercurous chloride with ammonia, while the latter may refer to the sweet taste of the compound.

CAMPHOR
This name comes from the Malay "kāpūr" meaning both "chalk" and the substance which we know as camphor. In Arabic it became "kā-fūr," and then "camphora" in Medieval Latin.

CARAMEL
From the Medieval Latin "canna mellis," sugar cane (see also "calomel") which became "caramelo" in French, meaning "delicately sweet."

CARBOLIC
This name is derived from the Latin "carbo" (coal) and "oleum" (oil) in reference to the fact that it is produced as an oily distillate from coal tar.

CARVACROL
This isomer of thymol is found in oil of Cretan Origanum, thyme, summer savory, and caraway. The name is from the French "carvi" (caraway) and the Latin "acer" (sharp) and "oleum" (oil).

CASEIN
The protein produced during the curdling of milk, first produced by Berzelius in 1812. The name comes from the Latin "caseus" meaning "cheese."

CATECHOL
This substance is present in the gambir plant, from which it is derived on treatment of the bark. The name for the plant in Malay is "kāchu."

CERESIN
This is a complex mixture of waxy hydrocarbons found in Boryslav, Lake Baiķal, Utah, and Texas. The name comes from the Latin "cera" meaning "wax."

CHALK
The name for this material is derived from the Latin "calx" or "calcis," meaning "stone" or "lime." In Anglo-Saxon the word became "cealc."

CHOLESTEROL
This monohydric alcohol is obtained as a fatty substance from egg yolk, gall, brain, and bile. Its name comes from the Greek "cholē" meaning "bile" and "stereos" meaning "solid."

CINNABAR
This mineral was known to the ancient Persians as "zinjifrah." In Arabic it became "zinjafr" and in old French "cenobre."

COPPERAS
The common name for ferrous sulfate. At one time it was synonymous with

"vitriol" (q.v.) and applied to the sulfates of zinc and copper as well. The name is derived from the Latin "cupri rosa" (the flower of copper) and in French became "couperose."

CORUNDUM

This is native crystalline aluminum oxide. The clear colored varieties are known as sapphire, oriental topaz and emerald, and ruby. The name is from the Sanskrit word for "ruby" which is "kuruvinda," which in Tamil became "kurundam."

COUMARIN

The French name for the Tonka-bean tree is "coumarou." Coumarin is obtained from the gum of this tree and is also known as "Tonka-bean camphor."

CRESOL

Literally, "oil of creosote." Its antiseptic properties have long been known and the name is derived from the Greek "kreas" meaning "flesh" and "sōzein" (to preserve).

CURARE

The dried aqueous extract of a vine used as an arrow poison by South American Indians. The name is from the Carib "uorari" (a poisonous herb). The initial "C" in our spelling is present because of the attempt to imitate the native pronunciation which is a "click."

DIGITALIN

The name comes from the fact that the flower of the plant, from which this substance is obtained, is finger-shaped. The word is Latin "digitalis" (like a finger).

EMERY

The word is derived from the old Greek name for this corundum-type mineral, "smiris." In French, the name became "emeri."

EOSINE

The color of this dyestuff is a delicate rose-red. It derives its name from the similarity between its shade and that of the morning sky, Greek "eos" (dawn).

EPSOM SALTS

This mineral, magnesium sulfate, is an important component of the spring waters in Epsom at Surrey, England. It is also found in the mineral waters at Seidlitz, Bohemia, from which the Seidlitz Powders take their name.

ERGOSTEROL

Literally, from the Greek, "the solid from ergot." The name "ergot," for the small pointed fungous growths which occur on rye and other cereals, comes from the French "argot," meaning "a spur."

FELDSPAR

A "spar" is a Middle Low German word, used by miners to describe any of various nonmetallic minerals which are usually cleavable and lustrous. The term was probably, originally based upon the Anglo-Saxon "spaeren" meaning "gypsum." Feldspar, then, from the German, means "field spar," the German "feld" (field) as the base.

FLOWERS OF SULFUR

The "flowers" of any substance has come to refer to a powdery form of that material, especially when produced by condensation of the sublimate. It is highly probable that it is a corruption of the word "flour."

FORMIC ACID

In 1670, S. Fisher first observed this compound in the products produced upon the dry distillation of red ants. The name is derived from the Latin "formica" meaning "ant."

FURANE

This is the hydrocarbon corresponding to the aldehyde, furfural, which Fownes produced in 1845 by distilling oat hulls and bran with sulfuric acid. The name is derived from the Latin "furfur" meaning "bran."

FUSEL OIL

This mixed amyl alcohol is found in liquor which has been insufficiently distilled. The German name for "bad liquor" is "fusel" which is derived from the German word "fuseln" meaning "to bungle a job," in this case, the distillation.

GLUCOSE

This simple sugar, also known as "grape sugar" is found in sweet wines. The name is directly derived from the Greek "gleukos" (sweet wine). It is associated with the etymology of "glycerine" which comes from the Greek "glykeros" (sweet) and became the French "glycerine" in the 19th century.

GRAPHITE

The most marked property of this mineral is, of course, its ability to leave a black streak upon surfaces, which is the basis for its being used in the manufacture of pencils. The name is from the Greek "graphein," meaning "to write."

GUANIDINE

The old Spanish Peruvian word for "dung" is "huanu." This is the base for the word "guano" which refers to the excrement of sea fowl. The compound, guanine, was first isolated from guano, and in 1861, Strecker oxidized guanine to guanidine.

GYPSUM

The name for this mineral comes from the Greek "gypsos" meaning "chalk," referring to the appearance of the substance. In Latin, the name became "gypsum."

SPIRIT OF HARTSHORN

This ancient name for ammonia, which still persists, comes from the fact that ammonia is produced during the distillation of the horn of the hart. The word "hart" is based upon the Anglo-Saxon "heort," meaning "stag."

HEMOGLOBIN

This name for the red coloring matter of blood, first isolated in crystal form by Hoppe-Seyler in 1862, comes directly from the Greek "haima" (blood) and the Latin "globus" (particle).

HIPPURIC ACID

This compound was first observed to be present in the urine of horses by Roulle in 1776. The name is derived from the Greek "hippus" (horse) and the Latin "urina" (urine).

HISTAMINE

This compound is produced during the decomposition of meat and other protein material. The Greek word for "tissue" is "histion," so that the name means "amine from tissue."

HORN SILVER

This is an old miner's term for the mineral form of silver chloride which occurs naturally in horn-like masses.

HYOSCYAMINE

This alkaloid is present in the leaves of the Egyptian Henbane. The name is based upon the Latin "hyoscyamus" which is "poison to fowl," from which "henbane" is derived. This comes from the earlier Greek "hyoskyamos" (the hog-bean).

HYPO

This is the familiar name used mostly in photographic terminology for sodium thiosulfate. The archaic name for the compound was sodium hyposulfite, and "hypo" is a short form thereof.

INDIGO

This coloring matter was originally obtained from plants which were indigenous to Bengal, Java, and the East Indies. Its name is derived from the Greek "Indikos" (Indian, of the Indies), becoming "indicum" in Latin, and finally "indigo" in Spanish.

KAOLIN

Kaolin is a very pure white clay used as the material from which porcelain paste is made. It was first found on a high hill in China. Its name is from the

Pekingese "kao-ling" meaning "high hill" and was adapted by the French to "kaolin."

KERATIN

This substance is present in hair, hooves, feathers and horn. Its name is derived from the Greek "keratos" (horn).

KIESELGUHR

A hard siliceous or diatomaceous earth, the name for which is derived from the German "kiesel" (flint) and "guhr" (sediment).

LANOLIN

The name LANOLIN, for the fatty material which is extracted from wool, was coined in 1885 by Liebreich from the Latin "lana" meaning "wool" and "oleum" meaning "oil."

LECITHIN

This is a complex lipoid rich in phosphorus which is found in brain and nerve tissue, white blood cells and egg yolk. It gets its name from the Greek word for "egg yolk" which is "lekithos."

LITHARGE

This monoxide of lead is found to occur naturally in silver-bearing lead ores. Its name is from the Greek "lithos" (stone) and "argyros" (silver) leading to "lithargyrus" and in Old French "Litarge."

LITMUS

This coloring matter is obtained from the leachings of several varieties of mosses and lichens. Its name is derived from the Old Norse "litr" (color, dye) and "mosi" (moss).

LUNAR CAUSTIC

This common name for silver nitrate has an etymological derivation based upon the fact that the compound is used for cauterizing purposes and contains the element silver, which was supposed, in days of Alchemy to be sacred to the moon or "Luna."

MALACHITE

This word which has been used both for the dyestuff Malachite Green and the compound, cupric carbonate, comes originally from the Greek "molochē" (mallow). The basis for this is the resemblance between the color of the material and that of the mallow leaf. The Greek word changed to "malochite" when the term was adopted by the French.

MALIC ACID

This compound, first discovered by Scheele in 1785, occurs in maple juice, and in apples and other fruit. The name is from the Latin "malum," meaning "apple" and in French became "malique," as the adjective.

MANNITOL

This simple sugar which is very widely distributed in nature is obtained from manna. Its name is derived from the Hebrew "mān" (manna) became "mannā" in Aramaic and "manna" in Greek.

MARBLE

The etymological basis for this name is the Greek word for "stone" which is "marmaros." In Latin this became "marmor," applied to marble and was taken into Old French as "marbre."

MENTHOL

This secondary alcohol, found in oils of mint, was first isolated by Gaubius in 1717 from oil of peppermint. Its name was coined by Oppenheimer in 1861 from the Latin "mentha" meaning "mint."

MICROCOSMIC SALT

The name for this compound is derived from the days of Alchemy, when it was found to occur in the urine of man. To the mystic alchemists, man was the "microcosm" (a world in miniature), and the salt was so named because it was a product of the bodily functions of this "little world."

MORPHINE

This sleep-producing alkaloid received its name from the Greek God of Slumber. The Greek "morphē" means "form" or "shape," and Morpheus literally means "the shaper" (of dreams).

MURIATIC ACID

This old name for hydrochloric acid is based upon the fact that it is obtainable from salt. The derivation is from the Latin "muria" meaning "brine" and "muriaticus" meaning "pickled."

NARCOTIC

This word and related ones like "narceine" and "narcosynthesis" are derived from the Greek "narkī" meaning "numbness, torpor." This changed to "narkōtikos" and was carried through as such through Medieval Latin and into the French.

NATRON AND NITER

The etymology of these words is badly confused. They come first from the Greek "nitros" which became "nitrum" in Latin, referring to the naturally occurring sodium carbonate. Lullius called potassium nitrate "sal nitri" to distinguish it from "nitrum." During the Sixteenth Century a change in terminology took place in which the old word "nitrum" became "natron," when referring to the Na_2CO_3 and "nitre" when referring to the nitrate.

NEATSFOOT OIL

This term is based upon the old German verb meaning "to possess" (geniessen). Since in those days, the possessions of a man were measured by the number of cattle he had, the verb was soon applied as a noun to cattle. It was taken into the Anglo-Saxon as "neōtan" and from that to various other languages, i.e., "nowt" (Scottish), "noz" (Old German), and "neat" in Anglo-Saxon meaning "calf or cattle." The oil itself is obtained from the feet of cattle.

NICOTINE

The name for this alkaloid is from that of Jean (Jacques) Nicot, the French ambassador to Lisbon who sent the first tobacco plants to Catherine de Medici.

NITER

See "natron."

OIL OF VITRIOL

This common name for sulfuric acid comes from the Medieval Latin "vitriolum," meaning "vitreous." This is because it is obtainable from the sulfates of copper, iron, zinc, etc. which occur in nature as glassy-appearing substances.

OPIUM

This alkaloid is obtained from the milky exudate of some of the poppy plants. The name is based upon the Greek "opos" meaning "vegetable juice," the diminutive of which, applied to the juice of the poppy plant is "opion."

ORPIMENT

This mineral form of arsenic sulfide is bright yellow in color. Its name is derived from the two Latin words "aurum" (gold) and "pigmentum" (pigment).

OXALIC

The acid is present in plants of the Rumex and Oxalis families especially. Its name, which is based upon the "sharpness" of the material comes from the Greek "oxys" (sharp, acid), becoming "oxalis" and then through the Latin and to French as "oxalique." Note the basis for Lavoisier's name for "oxygen," since he thought oxygen to be a constituent of all *acids*.

OZOKERITE

This name for impure ceresin was coined by Glocker in 1833 in reference to the odor of the material. It is derived from the Greek "ozein" meaning "smell" and "keros" meaning "wax." Note also that this is the basis for the name "ozone" referring to the odor of the gas.

PAPAVERINE

This is one of the opium alkaloids in which papaverine is present to the extent of about 1 per cent. Its name is derived from the Latin "papaver" meaning "poppy."

PARAFFIN

The characteristic behavior of these compounds is chemical inertness. The name refers to this property and is derived from the Latin "parum" (too little) and "affinis" (related or affinity).

PECTIN

These water-soluble vegetable juices are used in jelly making as a stiffening agent. The name is from the Greek "pegnynai" (to stiffen or make fast) and became "pektos" meaning "curdled or congealed."

PELARGONIC ACID

This common name is that for nonoic acid. It is obtained from the leaves of geraniums of the Pelargonium species. The flowers of these plants are long-beaked, which gives the species its name. The word is from the Greek "pelargos" meaning "a stork."

PEPSIN

The name for this digestive juice is derived from the Greek "peptein" meaning to "cook or ripen." In the same language the word was adapted to mean "digestion" (pepsis). In German it became "pepsin."

PERMUTITE

The material is used as a water-softening agent. Its name refers to the fact that water need only be passed through it to be changed from hard to soft. It is derived from the Latin "per" (through, by means of) and "mutare" (to change).

PETROLEUM

The name means literally "oil of rock." It is derived from the Latin "petra" (rock) and "oleum" (oil).

PHENOL

When this compound is produced from coal tar it comes out as shiny glistening crystals. The property is the basis for its name. It is derived from the Greek prefix "phaino" meaning "shining."

PHOSGENE

When this compound was first prepared by John Davy in 1812, he made it by exposing a mixture of carbon monoxide and chlorine to light. The name refers to this method of preparation and is from the Greek "phōs" (light) and "genes" (to be born).

PHTHALIC

This name is an adaptation of the word "NA*PHTH*ALENE," from which phthalic anhydride is derived.

PICOLINE

The name for this compound is based upon its place of occurrence, from the Latin "pix, picis" meaning "pitch."

PICRIC ACID

This name refers to the bitter taste of the compound and is derived from the Greek "pikros" meaning "bitter."

PIPERINE

This compound is derived from and is the active constituent of pepper, the Latin name for which is "piper."

PLUMBAGO

This is one of the names by which graphite is known. It is obtainable from lead ores (Latin for lead is "plumbum") and was often confused with galena and molybdenite. The true distinction among these three substances was not made until Scheele did so in 1779.

PROPIONIC

This name refers to the fact that the acid gives rise to the lowest fats of the paraffin acids. It is derived from the Greek "protos" (first) and "pion" (fat).

PRUSSIC ACID

This name is based upon the fact that hydrocyanic acid is obtainable from Prussian Blue.

PYRITES
One of the characteristics of the pyrites minerals is that they may be used to strike sparks. The name is from the Greek "pyr" (fire) and "pyrites lithos" (the stone which strikes fire).

PYROLUSITE
This native form of manganese dioxide has long been used to discharge the green and brown colors from molten glass by oxidizing ferrous compounds in the glass to ferric compounds. The name is derived from the Greek "pyr" (fire) and "louein" (to wash)—the color is then "washed out by fire."

PYROXYLIN
This form of nitrated cellulose is made by the action of mixed nitric and sulfuric acids on cellulosic materials such as cotton, paper, and wood. The fact that it burns so readily gives it its name derived from the Greek "pyr" (fire) and "xylon" (wood).

PYRROLE
Literally "fiery oil," see "pyr" compounds above and "oleum" (Latin for oil).

PYROGALLOL
This compound is prepared by heating gallic acid with water under pressure and takes its name from that fact. The name for gallic acid is derived from the Latin "galla" meaning "a plant gall."

PYRUVIC ACID
This compound which was obtained by heating grapes gets its name from that fact; Greek for "fire" is "pyr" and Latin for "grape" is "uva."

QUERCITOL
This compound is also called "acorn sugar" and is found in the fruit of various oaks. The Latin for "oak" is "quercus."

QUICKSILVER
This common name for the element mercury refers to the mobility of the metal and its resemblance to silver. Literally, the name means "living silver" from the Anglo-Saxon "cwic" (alive).

QUININE
This is the most important alkaloid of cinchona bark. The name is from the Peruvian word for "bark" which is "kina," which in Spanish became "quina."

RACEMIC ACID
This is the optically inactive dl-tartartic acid which occurs naturally in grapes. The name is from the Latin "racemus" (a bunch of grapes).

RAFFINOSE
This trisaccharide was first obtained by Loisean in 1876 during the refining of molasses. The name is derived from the French "raffiner" meaning "to refine."

REALGAR
This red sulfide of arsenic occurs in mines together with deposits of lead and silver. On exposure to light it crumbles to a powder. This gives rise to its name which is derived from the Arabic "rahj al-gahr" (powder of the mine) through the Spanish and Medieval Latin to "realgar."

RENNIN
This enzymatic material has the property of curdling at least 25,000 times its own weight of milk. The name is based upon the German "gerinnen" (clotted, curdled).

RIBOFLAVINE
This vitamin material is an orange-yellow powder found in whey, eggs, and is a ribose derivative. The yellow color gives to the name "flavine" from the Latin "flavus" (yellow), while the "ribo" is a transposition of "arabinose," a sugar of the pentose class.

SACCHARIN
The derivation of this word is from the Sanskrit "sarkara" meaning "gravel, sugar." This became, in Greek "sak-

charon" and "saccharum" in Latin. The name, of course, refers to its sweet taste, like that of sugar.

SALICYLIC ACID
This compound was first prepared by Piria in 1838 from salicin, a glucoside found in the bark and leaves of many willow trees. The name is derived from the Latin "salix" (willow).

SALT OF SATURN
This ancient alchemical name for lead acetate is based upon the fact that the metal was supposed to be under the control of the planet Saturn.

SALTPETER
This name for potassium nitrate comes from the Medieval Latin "sal petrae" (salt of the rocks) referring to the fact that the compound is found exuding from rocks during the oxidation of vegetable material contained therein.

SALVARSAN
This drug, first developed by Ehrlich in 1909, as a cure for syphilis, is also known as Arsphenamine. The name is derived from the fact that it is a reasonably safe material to use in the human body despite the fact that it contains arsenic; "salvus" means "safe" in Latin, while "arsenikon" is the Greek term for "arsenic."

SKATOLE
This compound, β-methylindole, derives its name from the fact that it is a constituent of fecal material. The word is from the Greek "skatos" meaning "dung."

SLAKED LIME
The process of "slaking" lime involves the addition of water to the hard lumps of calcium oxide which results in the crumbling of the material as it is converted to the hydroxide. The word is derived from the Anglo-Saxon "slaecian" (to grow slack, crumble, disintegrate).

SODA
The use of sodium bicarbonate, which is so closely related to the true "soda," sodium carbonate, in the treatment of digestive upsets and headaches which frequently ensue therefrom, has been known for ages. The name "soda" is based upon the Arabic "sudā," meaning "headache," becoming "soda" in Latin. In Medieval Latin, the term became "sodanum" and meant "headache remedy."

SPIRIT OF HARTSHORN
See *"Hartshorn."*

STARCH
A familiar property of starch is that of producing a stiff jelly-like mass when a solution of the material in water is permitted to cool. This is the basis for its name, which comes from the Anglo-Saxon "stearc" (stiff) which in Medieval English changed to "sterche."

STEARIC ACID
Stearic acid was first recognized in 1813 by Chevreul who found it to occur as the glyceride in tallow and other animal and vegetable fats and oils. The name is derived from the Greek "stear" (tallow, suet) and became "stearine" in French.

SUBERIC ACID
This compound, hexamethylendicarboxylic acid, is made by heating castor oil or cork with nitric acid. The common name is derived from the Latin "suber" meaning "cork," and the name for the acid became "suberique" in French.

SUCCINIC ACID
In 1546, Agricola found succinic acid in the distillate from amber. It also occurs in various fossils and fungi. The name is derived from the Latin "succinum," meaning "amber" and the name for the acid became "succinique" in French.

TAURINE
This amino acid was first found in ox bile, in which it occurs combined with cholic acid. It is also present in flesh of oxen, muscle, oysters, and shark's blood.

The name is from the Latin "taurus," meaning "bull."

THEBAINE
This substance is an alkaloid which takes its name from a type of Egyptian opium produced at Thebes, the name for which is derived from the Greek "Thēbē."

THEELIN
This name is synonymous with "Estrone," the female hormone. The name is from the Greek "thēlys" (female).

THEOBROMINE
This alkaloid takes its name from the fact that it is obtained from Oil of Theobroma, more commonly known as "Cocoa Butter." Theobroma is so-called because of the highly prized nature of the material and is derived from the Greek "theos" (God) and "broma" (food).

THEOPHYLLINE
This alkaloid was first isolated from tea leaves by Kossel in 1885. The name is from the New Latin "thea" (tea, the tea plant) and the Greek "phyllon" (leaf).

THYMOL
Although this compound is now made synthetically from m-cresol or p-cymene, it was first obtained from Oil of Thyme by Neumann in 1719. It takes its name from the Greek "thymon" (the thyme plant).

THYROXIN
This compound is the hormone produced by the thyroid gland, the name for which is derived from the Greek "thyreos" (shield) and "eidos" (form), in reference to the shape of the gland.

TIGLIC ACID
This acid, l-methylcrotonic acid, occurs as an ester in croton oil. The name is from the New Latin "tiglium" (the croton-oil plant).

TOCOPHEROL
This compound is also known as Vitamin E, or the anti-sterility vitamin. Its name refers to the fact that it is apparently necessary for fecundity and is derived from the Greek "tokos" (offspring) and "pherein" (to bear).

TOLUENE
The name for this compound is derived from the fact that it may be obtained from Tolu Balsam by distillation. The resin is obtained from the type of pine tree which is found at Santiago de Tolu in Colombia.

TRONA
This is a word of Swedish origin derived from a reduced form of the Arabic "natrūn" (See NATRON).

TRYPSIN
This is the proteolytic enzyme of the pancreas which takes its name from the Greek "tryein," meaning "to wear out" and therefrom "to digest" and the name "*pepsin.*"

TURPENTINE
This familiar material takes its name from the Greek "terebinthos" (the turpentine tree) and changed through Latin and Old French to "terbentine."

ULTRAMARINE
This blue pigment occurs in nature as the mineral, lapis lazuli. Originally, this substance was brought to Europe from Asia from "beyond the sea." Its name is from the Latin "ultra" (beyond) and "marine" (the sea).

UROTROPINE
This compound has been used extensively in the medication of urinary difficulties, and is mainly excreted by the bladder. The fact that it appears in urine is responsible for its name which is derived from the Greek "ouron" (urine) and "tropos" (to turn).

VALERIC ACID
This substance takes its name from the root of the valerian plant in which it occurs. In early times, the root of this plant was noted for having great

medicinal virtue and the name is from the Latin "valere," meaning "powerful."

VANILLIN
The seeds of the vanilla plant are contained in little pods and so the name for the plant came from the Latin "vagina" in reference to this fact. This changed to "vaina" in Spanish and the diminutive form in this language gave rise to "vainilla."

VASELINE
This word was coined from the German "wasser" (water) and the Greek "elaoin" (olive oil).

VERDIGRIS
This literally translated from the Old French means "the green of Greece." This is in reference to the green appearance observed on the surfaces of Ancient Greek relics as the result of corrosion of the copper used in their construction.

XANTHOPHYLL
The name for this yellow pigment of various leaves and vegetables is directly derived from the Greek "xanthos" (yellow) and "phyllon" (leaf).

XYLENE
This compound was first obtained by Cahours in 1849 from the crude distillate of wood. The name is from the Greek "xylon," meaning "wood."

ZEOLITE
This mineral usually occurs as a secondary mineral in cavities in lava. The name is from the Greek "zein" (to boil) and "lithos" (stone), referring to the lava in which it is found.

ZYMASE
This enzyme has the property of acting upon glucose and other carbohydrates to produce water and carbon dioxide in a yeast-like fashion. The name is from the Greek "zyme" (leaven).

EDWARD EMBREE WILDMAN

THE passing of Dr. Edward Embree Wildman was recently brought to the attention of the Editor. His death occurred on May 6, 1956. Dr. Wildman is well remembered by the earlier members of N.A.R.S.T. He served as Vice-President and member of the Executive Committee on two different occasions—1932–33 and 1934–35.

According to *Leaders in Education* and *American Men of Science,* Dr. Wildman was born in Selma, Ohio, October 19, 1874. He received a B.S. degree from the University of Pennsylvania in 1904, an M.S. degree in 1908, and a Ph.D. degree in 1912. He was assistant in biology at the University of Pennsylvania 1902–04, a teacher of biology at the Central High School in Philadelphia 1906–12, head of the Science Department West Philadelphia High School for Girls 1912–26, and Director of Science Education, Board of Education, Philadelphia Public Schools 1926–42. He retired from this position in 1942. Summer school teaching included Woods Hole, 1908–11; Principal Demonstration High School 1921–25; instructor in zoology at University of Pennsylvania 1919–21. He was research associate of the Academy of Natural Sciences, Philadelphia 1944. He was a member of Sigma Xi.

Publications included: *Teaching Fractions* published by Plymouth Press, 1922; *Elementary Science By Grades, Book 4* (coauthor Persing), D. Appleton Company, 1929; *Our Changing Year,* Thomas Nelsons and Sons, 1937; and *Penn's Woods,* Christopher Sower Company, 1932.

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